THE UNIVERSITY OF MICHIGAN
DEC 17 1959
ENGINEERING LIBRARY

JOURNAL
OF THE INSTITUTION OF
ELECTRICAL ENGINEERS

VOLUME 5 NO. 53 NOVEMBER 1959

THE UNIVERSITY OF MICHIGAN
DEC 17 1959
ENGINEERING LIBRARY

VOLUME 5 NUMBER FIFTY-NINE NOVEMBER 1959

JOURNAL OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 *Telephone* COVENT GARDEN 1871 *Telegrams* VOLTAMPERE PHONE LONDON

PUBLISHED MONTHLY PRICE SEVEN SHILLINGS ANNUAL SUBSCRIPTION TWO POUNDS

Contents

623 **Railway electrification**

624 **Dual-purpose electro-Diesel locomotives**

625 **Performances of electric locomotives of the French National Railways**
by F. NOUVION

629 **The Incorporated Benevolent Fund: Annual Report**

630 **Applications of photoelectric cells**
by F. A. BENSON, D.ENG., PH.D., ASSOCIATE MEMBER

636 **SETS conference 1959**

637 **Electrical floor-warming**
by P. WALSH, B.E., ASSOCIATE MEMBER

641 **Changes in the Bye-laws of The Institution**

645 **Special General Meetings on the 9th April, 25th June and 18th August 1959**

649 **Special Advisory Committee of the Council**

650 **A review of the *Proceedings*, Parts A and B**
(*details are given in the adjoining column*)

657 **Correspondence**

658 **Obituary**

660 **Papers and monographs published individually this month**
(*details are given in the adjoining column*

662 **Some recent books**

665 **Library accessions**

666 **Elections and transfers**

666 **District Meetings**

667 **Forthcoming events at Savoy Place**

667 **British Nuclear Energy Conference**

667 **Contents of the current *Proceedings***

668 **Announcements to members**

672 **Bulletin of the Sections**

675 **London report**

675 **News from the Centres**

676 **News from abroad**

677 **Officers of The Institution**

BACK COVER **Index of advertisers**

650 A review of the *Proceedings*, Parts A and B

High-power u.h.f. television transmitters	T. S. Robson and T. M. J. Jaskolski
Coastal deviation of radio waves	B. G. Pressey, G. E. Ashwell and R. Roberts
Coal-mining and electricity	A. P. Foster
Logarithmic motor	Prof. F. C. Williams, E. R. Laithwaite, J. F. Eastham and L. S. Piggott
A.M. noise spectrum in reflex klystrons	H. Häggblom
Spherical induction motors	Prof. F. C. Williams, E. R. Laithwaite and J. F. Eastham
Balanced aerial connected directly to coaxial cable	G. D. Monteath and P. Knight
Alternator with field-form envelope control	J. W. Pannell

660 Papers and monographs published individually this month

PAPERS

Low-pressure resins for high-voltage switchgear	T. R. Manley, K. Rothwell and W. Gray
Field suppression of turbo-alternators	J. R. Hill, A. Hunt, W. J. Joyce and D. H. Tompsett
Multiple-radio-channel routes	B. B. Jacobsen
Protection of semiconductor rectifiers	D. B. Corbyn and N. L. Potter

MONOGRAPHS

Optimization of non-linear filters	J. K. Lubbock
Copper and iron losses in variable-load transformer	G. S. Brosan and D. O. Bishop
Non-uniform transmission lines	L. Solymar

Railway electrification

WORK on the 25kV single-phase 50c/s electrification programme of British Railways proceeds steadily. On the cover is shown an Eastern Region photograph of overhead equipment for the London, Tilbury and Southend line. The structure carries the 'out of running' and 'in running' cantilever assemblies at an overlap span. Here the 'out of running' catenary wire is being clamped in position. Its associated contact wire when run out will be fixed to the lower horizontal tube. A temporary pulley is attached to the other cantilever assembly ready to receive the catenary supporting the 'in running' contact wire, the registration arm for which is temporarily tied upright. Polythene bags protect the insulators from unnecessary pollution before the line is energized.

On the 19th October work began on the erection of masts for the Liverpool–Crewe electrification. Two new power signalboxes are to be built on that 36-mile line which will be equipped with colour-light signals.

The Foreword on p. 623 gives a general assessment of the electrification programme. An article on p. 625 discusses the performances of electric locomotives of the French National Railways

Secretary W. K. BRASHER, C.B.E., M.A., M.I.E.E. *Editor* W. G. ASKEW, M.C.

© 1959: The Institution of Electrical Engineers

Advertising Office TERMINAL HOUSE, GROSVENOR GARDENS LONDON S.W.1 *Telephone* SLOANE 7266 *Telegrams* INDULICITY, SOWEST, LONDON

The Institution is not as a body responsible for the opinions expressed in the *Journal* unless it is stated that an article or a letter officially represents the Council's views

JOURNAL

OF THE INSTITUTION OF ELECTRICAL ENGINEERS

SAVOY PLACE LONDON W.C.2 VOLUME 5 NUMBER 59 NOVEMBER 1959

RAILWAY ELECTRIFICATION

THE advantages of electricity as the motive power for railways have been evident to at least two generations of electrical engineers. The development of residential traffic in what is now the Southern Region of British Railways would not have been possible but for electrification. The increase in foreign travel has made well known the extent of railway electrification in Europe. The electrification now in progress on British Railways may therefore be considered against a background of surprise that it has not come more quickly, the theme of an article in the January 1955 *Journal*, p. 3.

Our railway lines were substantially complete at the turn of the century when no other motive power but steam was commercially available. In those days coal and labour were cheap and the steam locomotive was a cheap and simple, if inefficient, engine. Today all is changed, and in addition alternative forms of transport by road and air make modernization of the railways essential if they are to give the competitive and efficient service which the national economy demands. Electrification is prominent in the British Transport Commission's Modernization Plan described in two White Papers presented to Parliament, one in October 1956 and the other in July 1959.

By the end of 1963 electric traction should be in operation over some 600 route miles additional to the 1000 route miles of electrified track in service at the beginning of 1959. During 1959–63 electrification schemes including associated rolling stock and engineering works are estimated to need £265 million, about a quarter of the estimated railway investment expenditure.

The absence of dirt and the predictability and consistency of performance with electric traction permit fast, comfortable and punctual trains, but its main advantage is the elimination of the prime mover from the motive-power unit whereby its power/weight ratio is greatly increased. Efficiency and availability are improved, and the cost of maintenance is reduced. The ease with which electricity can be controlled makes it possible to spread the motors throughout the length of a train. This, the natural characteristic of the d.c. series motor, and the simplicity of the third-rail system explain why it was adopted for the earlier electrifications in this country.

For hauling freight trains however the amount of current tends to be a limiting factor. But new techniques for converting from alternating to direct current have developed rapidly with the result that late in 1956 the Commission decided to standardize on a system using h.v. single-phase overhead-contact line fed at 50c/s except on those parts of the Southern Region where extensions of the existing system were economically essential.

Not the least of the advantages of the new system is that while it can retain the well tried series d.c. motor it also permits the incorporation of new techniques, particularly those of electronic engineering. Another reason for this radical change in method at the start of a fixed time programme is that 25kV had been adopted for this purpose abroad and there were obvious merits in using it here.

The main objection to electrification has been and remains its high capital cost. Whereas the motive-power units are for equal performance less than half the price of the Diesel alternative now available, the cost of fixed equipment to bring power to the trains must always so far as one can foresee be considerable.

Any electrification, and particularly the present system, imposes severe demands on other engineering departments of the railways, notably on the civil and signal engineers. To assist the former a lower voltage (6·25kV) is being used in this country where the cost of obtaining the necessary clearance for 25kV would be prohibitive. This has posed interesting problems in the design of the pantographs used for current collection and has required the development of an automatic changeover of the transformer connections so that the transition can be made without imposing an additional task on the driver and without interference with the progress of the train. Other expedients such as special insulation of particular isolated bridges in a zone which is otherwise suitable for 25kV working are in an advanced state of development.

A large programme of improving signalling is naturally a part of the Modernization Plan. This is essential but with electrification some restrictions are imposed on track circuiting and telecommunication cables. It is also necessary to avoid interference with Post Office circuits, and trial is at present being made of several technically practicable methods of achieving all these objects simultaneously.

The programme in the Modernization Plan and recently reaffirmed embodies the electrification of the main line from Euston to Manchester and Liverpool (including the lines serving Birmingham and Stoke); of the suburban lines from Liverpool Street to Enfield, Chingford and Bishop's Stortford and from Fenchurch Street to Tilbury and Southend; of the Glasgow suburban lines; and of the Colchester–Clacton branch as one of the proving grounds for the new system. It has also been decided to convert the existing 1500volt d.c. overhead electrification from Liverpool Street to Chelmsford and Southend (Victoria) to the new system and to electrify from Chelmsford to Colchester.

In spite of the change in system part of the Manchester–Crewe electrification was energized for trial running and training of drivers in October 1958, and the Colchester–Clacton electrification has been in public service since March 1959.

The conversion of the existing Eastern Region suburban lines and the completion of the Eastern Region electrification are planned for 1960 (Enfield–Bishop's Stortford) and 1961 (Southend). The Manchester–Crewe section of the London Midland Region electrification is expected to be finished in September 1960 and now incorporates a major rebuilding of London Road Station, Manchester. Steps are being taken to accelerate materially the completion of the rest of the London Midland Region main-line electrification originally planned for 1967. The Glasgow electrification is proceeding according to programme for completion of the first stage in 1960.

These schemes involve overhead equipment on over 900 single-track miles and the production of 289 motor coaches and 724 trailers for multiple-unit trains. In addition one hundred 3300h.p. locomotives are in construction, 60 of them contractor-built. The mechanical parts of the remaining 40 locomotives are being made in railway workshops.

The electrical equipment of the rolling stock embodies various methods of converting from 25/6·25kV a.c. to direct current. Most employ various forms of mercury-arc rectifier, but germanium and silicon are also being used. Germanium rectifiers are being used for the conversion of the existing 1500volt equipments to work on the new system. The railway-built locomotives will have semiconductor rectifiers and provision for rheostatic braking. Both h.v. and l.v. tap-changers are being used for speed control.

The first stage of the extension of the Southern Region electrification to Ramsgate and Dover involving the equipment of over 200 single-track miles and 53 four-car and 63 two-car trains was brought into public service on the due date in June 1959. Work proceeds apace on the remaining stages to complete the electrification of the eastern and central sections.

The profession may well be content with the expressed view of the Commission that, although either Diesel or electric traction will give a satisfactory financial return and Diesel traction will produce improvements more quickly and with less disturbance to traffic, in the long run electrification will create the better railway.

DUAL-PURPOSE ELECTRO-DIESEL LOCOMOTIVES

THE British Transport Commission have placed orders with British Railways workshops at Crewe, Doncaster and Swindon for a further 80 main-line Diesel-powered locomotives. This brings to over 400 the number of main-line Diesel locomotives to be built in railway workshops for the modernization programme. These new orders are valued at £80 million. Six of the locomotives will be of the electro-Diesel type which is entirely new to Britain. They will be built by the Doncaster Works for the Southern Region. The remaining 74 locomotives will have Diesel engines of 2700h.p. with hydraulic transmission and are for the Western Region. Swindon Works will build 35, and 39 are to be constructed by the locomotive works at Crewe. Deliveries of both types of locomotive will begin in 1961.

All 74 Diesel-hydraulic locomotives have been ordered for a further stage of the Western Region's programme for the complete replacement of steam by Diesel power on all rail services in the West of England and in the Bristol area including all principal passenger and freight trains to and from London. This is an extension of the scheme announced late in 1957 for the complete operation by Diesel locomotives of all rail services to the west of Newton Abbot and of some through trains between London and the West.

The six electro-Diesel locomotives are designed to operate as Diesel-electric locomotives on non-electrified sidings and main lines, employing electric power supplied by a 600h.p. Diesel-engine-driven generator, or as electric locomotives when on electrified lines. These locomotives are for the Southern Region. It is hoped that greater flexibility of operation will result which may lead to a reduction in the total number of locomotives needed for partially electrified areas.

Performances of electric locomotives of the French National Railways

621.335.2(44)

With the electrification programme of British Railways well under way interest naturally turns to the experiences of our neighbours. Some outstanding performances have been and are being achieved by the French National Railways as regards both the speed of passenger trains and the loads pulled by light locomotives.

Monsieur Nouvion who is with the Société Nationale des Chemins de Fer Français describes in this article the development of the BB and CC classes of locomotives. The article was first received on the 21st October 1958 and in finally revised and translated form on the 16th April 1959.

F. NOUVION

In many fields truly remarkable performances are achieved every day in electric traction on the French National Railways and the most spectacular are naturally to be found in the speeds obtained by electric locomotives in passenger service.

Passenger trains on long journeys

Using electric traction 30 towns and cities in France are linked with Paris by services having speeds greater then 62m.p.h. (see Fig. 1), and every day some 180 electric trains cover a total distance of more than 27000 miles at an average speed greater than 62m.p.h. These 180 trains include:

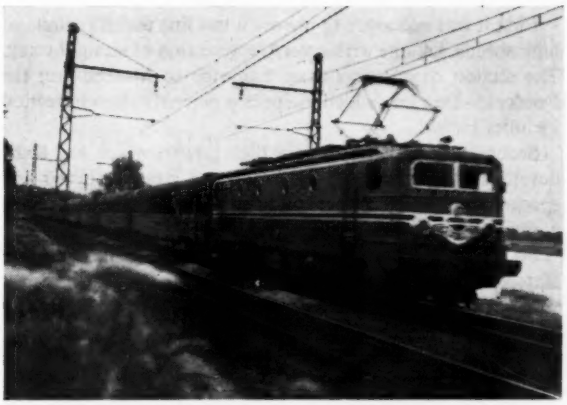
28 running at average speeds greater than 68m.p.h. covering in all 7341 miles

10 running at average speeds greater than 74·5m.p.h. covering 1705 miles

2 running at average speeds greater than 77·5m.p.h. covering 658 miles.

1 *Electric traction at more than 62m.p.h. between Paris and 30 towns*

The towns served are those with more than 15000 inhabitants and frontier towns; figures indicate average speeds to and from Paris



2 *The Mistral*

Two French trains stand out from the rest because of their high commercial speeds over long distances. First we have the train known as the *Mistral* which connects Paris with Lyon (318 miles) in four hours including a stop at Dijon which means a commercial speed of 79·5m.p.h. This train holds the world record for average speed over a stretch of more than 310 miles. There is also the *Sud-Express* which links Paris with Bordeaux (360 miles) without a stop in 4h 58min, i.e. at a commercial speed of 72·7m.p.h. Fig. 2 shows the *Mistral* at full speed between Dijon and Lyon.

Peak speeds—world speed record

There can be no doubt then that French passenger trains are fast. But what is the safety margin with the rolling stock?

It was for the purpose of measuring this margin that very-high-speed tests were carried out in February 1954 and March 1955.

People began to talk of high speeds in France—more than 87 m.p.h.—with the advent of total-adhesion locomotives, first the CC type 7100 (Fig. 3) and then the BB high-speed locomotives 9001 to 9004 (Fig. 4) which subsequently gave rise to the BB 9200 series (Fig. 5).

In February 1954 with locomotive CC 7121 hauling three coaches a speed of 151 m.p.h. was reached without the rolling stock being modified in any way either electrically or mechanically. The speed was limited not by the stability of the locomotive but by the speed of rotation of the motors. In point of fact, using the normal gear ratio for these locomotives, the motors reached the overspeed limit at 151 m.p.h. In order to exceed this speed it was necessary to change the gear ratio.

In this way it was decided to carry out tests at still higher speeds with a locomotive of the class CC 7100 (locomotive CC 7107) and to put in competition with it one of the prototype BB locomotives, the 9004, which had just completed its first trials.

The speed which it could reasonably be expected to reach might be greater than 186 m.p.h., and the preparatory studies were carried out on this basis.

Test preparations

First it was necessary to choose a test line which permits of high speeds, i.e. one with a very long section of straight track. The section chosen was from Lamothe to Morcenx on the Bordeaux–Dax line which includes a perfectly straight section 29 miles long.

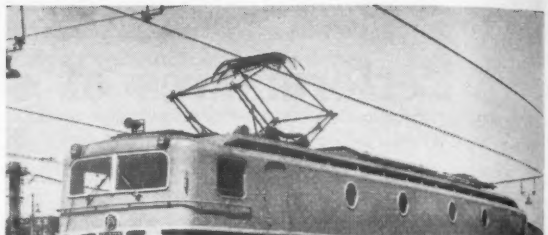
Secondly because of the very high powers which had to be developed the power supply to the line was reinforced and special arrangements were made so as to obtain an average along the line of 1800 volts.

So far as the locomotives are concerned, as we have already stated above it was necessary to modify the gear ratio. But it was not sufficient just to consider the question of the racing of the motors. The most important thing was to select the gear ratio so that the full power of the motors could be utilized at maximum speed.

With these locomotives the continuous power can be developed only within a very closely defined speed range, and this range is wider the lower the minimum excitation capacity of the motors. In normal service conditions this is 27% on the CC locomotive and 46% on the BB locomotive.

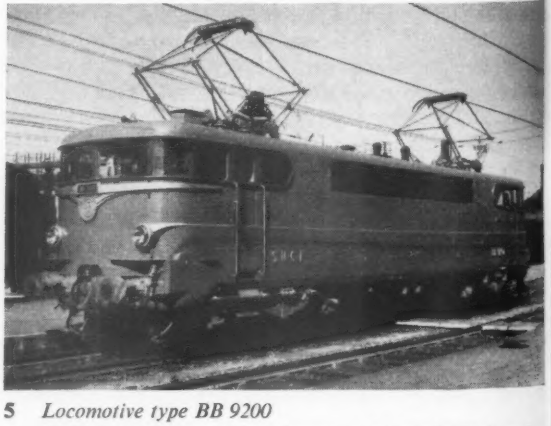
Would it be possible to maintain these figures at the peak output required for high-speed trials? With the CC locomotive which is equipped with six compensated and half-voltage 6-pole motors it was possible to reach the maximum speed by using the running stages at very low excitation figures (25%). On the BB locomotive, on the other hand, which is equipped with four uncompensated and full-voltage 4-pole motors it was wiser to set a higher minimum excitation figure (of the order of 65%).

Having thus defined the new characteristics of the motors a check was made on the test-bed of the behaviour of the motors at the various speeds adopted, from the point of view both of heating and of commutation. As regards heating, one motor of each locomotive was subjected to the working



3 *Locomotive type CC 7100*
4733 h.p. at 60·9 m.p.h.
Maximum speed in service 99·4 m.p.h.

4 *Locomotive BB 9004*
4289 h.p. at 60 m.p.h. Maximum speed in service 87 m.p.h.
On the front of the locomotive can be seen the protective grille fitted for the trials at 205·7 m.p.h. carried out in March 1955



5 *Locomotive type BB 9200*
5492 h.p. at 56·9 m.p.h. Maximum speed in service 99·4 m.p.h.

cycle shown in the Table below which corresponded to what would be required of it during the trials.

In continuous-rating conditions the current through the motors of these two locomotives fed at 1350 volts is 850amp for the CC 7107 and 520amp for the BB 9004.

Time	Corresponding position on line	CC 7107			BB 9004		
		I motor	*V* motor	running notch	*I* motor	*V* motor	running notch
min		amp	volts		amp	volts	
0–1	starting from Facture and running on the	1400	500	full field	1050	600	full field
1–3	stretch before Lamothe	0	0	0	0	0	0
3–5·5	high-speed	1300	750	field 35%	1050	1200	full field
5·5–7·5	trials	1300	750	field 25%	900	1500	field 85%
7·5–10·5	proper	1300	925	field 25%	900	1850	field 75%

It should also be pointed out that a pantograph was designed for the purpose of collecting a large amount of current at high speed. So far as the mechanical part was concerned, cogwheels and pinions were replaced and those parts which had to withstand considerable stresses were subjected to special tests and inspection.

Streamlining for world record

Finally, improving the streamlining of the trains by doing away with the ventilators of the carriages, the running-boards, and the handles for climbing up, by completely enveloping with sheet rubber the space between the locomotive and the first coach and between each coach, and lastly by fixing an appendage at the rear of the last coach, made it possible to reduce the resistance to movement by about 20%.

6 *Locomotive BB 12006 hauling a heavy train on a line in north-east France*

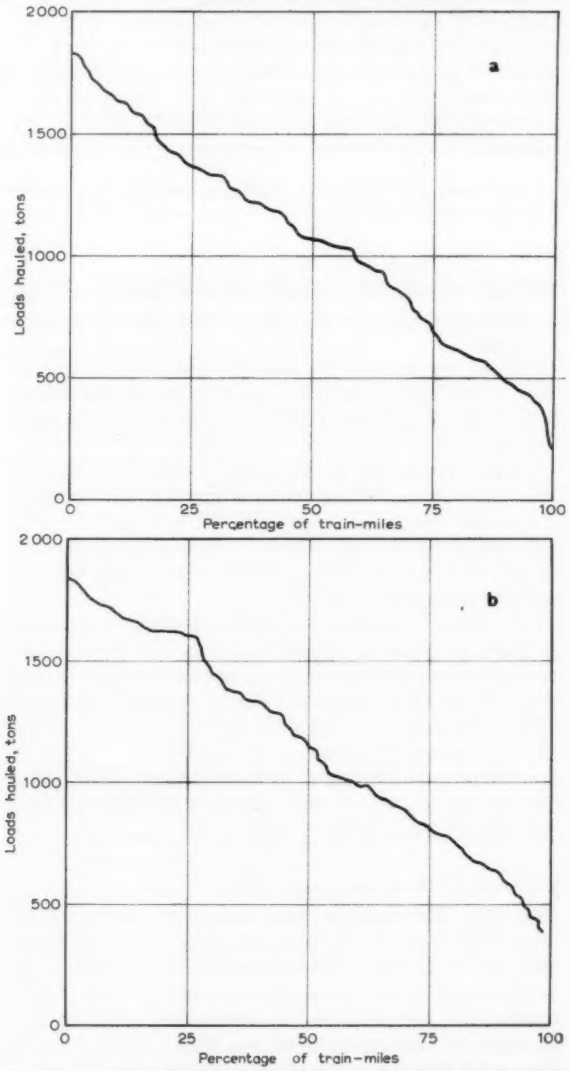
On the 28th March 1955 with the line guarded throughout the whole length and all traffic prohibited on the neighbouring track the locomotive CC 7107 attached to three coaches weighing 101·9 tons* attained a speed of 205·7m.p.h. with a maximum power absorbed at the pantograph of 8200kW.

On the 29th March 1955 the locomotive BB 9004 (Fig. 4) pulling three coaches weighing 101·9 tons attained the same speed with a maximum power absorbed at the pantograph of 9400kW.

In this way these two locomotives established the world rail-speed record.

Freight loads handled

Performances which are not so well known to the public at large but which are none the less valuable to the railways are those which consist in hauling very heavy goods trains with light locomotives.



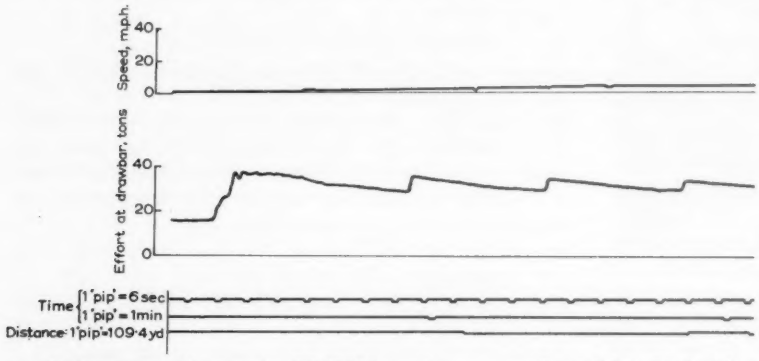
7 *Locomotive BB 12006: classified hauled loads on lines with a gradient of 1 in 100*

a 4th quarter 1955
b 1st quarter 1956

*To aid comparison the metric tons used in the original MS. have been converted to British (long) tons

We owe these performances to the advent of traction by single-phase 50c/s current and in particular to that of BB type 82·7-ton locomotives with ignitron rectifiers belonging to series 12000.

Originally designed to haul 738 tons up a gradient of 1 in 100 the first locomotives delivered succeeded in hauling 1378 tons up such a gradient. These results showed that the qualities of adhesion of these locomotives had not been exhausted.



8 *Performance of locomotive BB 12006 starting on a gradient of 1 in 93·5 with a train weighing 2386 tons*

This led the designers to alter the transmission ratio as from the sixth locomotive with a view to increasing the tractive effort at the rim without in this way overloading the ignitron rectifiers.

The first locomotive of the second batch, the BB 12006, after numerous satisfactory trials at starting on a gradient of 1 in 100 with trains weighing 1575, 1673 and then 1975 tons was detailed for eight months to take turns on duty with the CC 98·4-ton locomotives which were pulling 1821-ton trains up gradients of 1 in 100.

Fig. 6 shows the locomotive BB 12006 pulling a coal train on a line in north-east France. Figs. 7a and 7b show the classified loads of trains pulled by the BB 12006 in relation to the percentage of train-miles during the fourth quarter of 1955 and the first quarter of 1956. Fig. 7b shows that 30% of the trains have a load greater than 1476 tons.

At present the loading in normal running conditions of BB-type ignitron locomotives belonging to series 12000 is 1624 tons on a gradient of 1 in 92·5.

World record for starting load

In May 1957 during the course of trials without any special preparation the BB 12006 locomotive gave even better performances. Trains were started from standstill on a gradient of 1 in 93·5 with tonnages of 1981, 2087, 2188 and 2386, thus establishing the world record for starting load per adherent ton of locomotive on this gradient.

During the course of these trials the train was partly on the straight and partly on a curve with a radius of 550 or 650yd. The coefficient of adhesion was found to be 47%. Fig. 8 shows the recordings of the speed and of the tractive effort at the draw-bar as determined during the last start.

From the results it seems that these locomotives can find their full utilization only on lines with heavy traffic.

The French National Railways have therefore studied another type of BB locomotive weighing less than 78·7 tons which offers traction capacities which still cover a very large proportion of the traffic requirements.

The BB 16500 class

In order to satisfy this programme a new series of locomotives is under construction. This is the BB 16500 series the plans of which are shown in Fig. 9.

A special feature is that they have only one motor to each bogie, and the two axles of the bogie are coupled together mechanically by a system of gears. This arrangement brings with it new advantages from the point of view of adhesion.

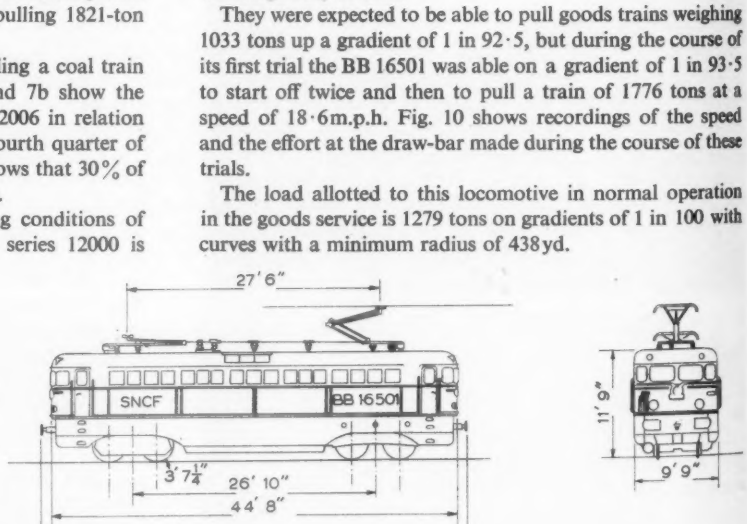
There is another feature which should be noted: they have two transmission ratios, one for goods service at a maximum speed of 53m.p.h. and the other for passenger service with a maximum of 87 m.p.h.

It is possible to change from one to the other in a matter of a few minutes.

The first locomotive of this series was delivered on the 31st July 1958. It weighs 66·9 tons, but the subsequent units will weigh only 65 tons.

They were expected to be able to pull goods trains weighing 1033 tons up a gradient of 1 in 92·5, but during the course of its first trial the BB 16501 was able on a gradient of 1 in 93·5 to start off twice and then to pull a train of 1776 tons at a speed of 18·6m.p.h. Fig. 10 shows recordings of the speed and the effort at the draw-bar made during the course of these trials.

The load allotted to this locomotive in normal operation in the goods service is 1279 tons on gradients of 1 in 100 with curves with a minimum radius of 438yd.



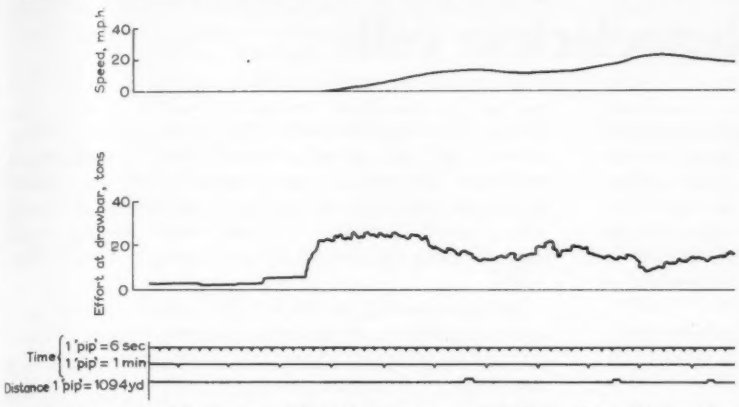
9 *Plans of a BB 16500-class locomotive*

Summary

Each day more than 180 passenger trains drawn by electric locomotives run at average speeds of over 62m.p.h.; the *Mistral* averages 79·5m.p.h. from Paris to Lyon and the *Sud-Express* 72·7m.p.h. from Paris to Bordeaux.

The CC 7100 series and locomotives BB 9001–9004 were modified to undergo safety tests at high speed, and these modifications and other test preparations are described.

As regards freight the transmission ratio of the BB 12000 series of locomotives using ignitron rectifiers was modified, and on trial the BB 12006 broke the world record for starting-load on a gradient of 1 in 93·5. It was found however that this series was economic only on lines with heavy traffic, and a new series of locomotives, BB 16500, is now being constructed. Its design features and performance are given.



10 *Performance of locomotive BB 16501 starting on a gradient of 1 in 93·5 with a train weighing 1776 tons*

The Incorporated Benevolent Fund: Annual Report

THE Report of the Court of Governors of the Incorporated Benevolent Fund was presented at the annual general meeting of the members of the fund on the 28th October 1959. The report together with the accounts was circulated with the September 1959 *Journal*.

The total capital of the fund stood at £157283 on the 30th June 1959.

Subscriptions and donations during the year showed a continued increase from £15475 (in 1958) to £16110 which was largely attributable to the Presidents' appeals circulated with the *Journal* in December 1957 and December 1958.

These appeals and other efforts, in addition to producing increased annual subscriptions, resulted in 400 new deeds of covenant raising the fund's annual income (with refund of income-tax) by approximately £800.

The cost of grants plus management and maintenance charges was £15081, and although this was a little less than the sum from subscriptions every effort must be made to continue to increase the income annually as only by this means can the Court of Governors increase the assistance given to beneficiaries.

Grants to 142 beneficiaries with 122 dependants came to £10038—an average of £73 per beneficiary.

Seven legacies were received amounting to approximately £4000. Further royalties accrued on a book.

The number of new cases was 23. As has happened in previous years, some grants have been discontinued by reason either of death or of improvement in circumstances of the beneficiaries concerned.

The fund now has four beneficiaries resident in the Crossways Trust homes at West Worthing, Brighton and St. Leonards-on-Sea which are proving the ideal solution for those who although not infirm need accommodation where a certain amount of attention is provided.

Refund of income-tax. A sum of £2149 was recovered from the Income-Tax Commissioners owing to the kindness of members who subscribed by covenant. A further £5000 could be saved if all subscribers of over 10s. per annum would use the covenant to subscribe for seven years, a procedure which involves no other obligation.

Homes Fund. The total amount received in subscriptions and donations from the inception of the fund to the 30th June 1959 was £44908, and in addition 233 members have signed deeds of covenant which enable a further £200 per annum to be recovered from the Commissioners of Inland Revenue. There are 30 people resident on 'The Chesters' estate; all the houses and flats are occupied and it is the intention of the Court to build more accommodation as funds become available.

Wilde Fund. The accounts of the Wilde Fund were published in the August 1959 *Journal*, p. 456.

Lord Hirst Fund. On the 30th June 1959 the fund comprised:

Capital-account investments	£11543 3s. 10d.
Income-account investments	£3989 11s. 2d.

which produce an annual income of about £627. The uninvested balance of the income account was £38 3s.

Grants totalling £250 were made from this fund during the year.

Staff. It was with great regret that the Court learned that Mr. H. J. Nunn wished to retire from the position of warden of 'The Chesters' estate in September 1959. He had been with The Institution for 56 years and warden for nine years. The Court have elected Mr. H. V. Steele the new warden; he took over his duties on the 1st October 1959.

Applications of photoelectric cells

621.383:621.317.18:621-52

The number of possible applications of photocells in industrial practice is enormous. There are few areas of human activity in which photoelectricity does not play a part. Some applications are briefly discussed in this article which was inspired by one of the themes of Dr. Benson's Chairman's Address to the Sheffield Sub-Centre entitled 'The origin and growth of electronics' delivered at Sheffield on the 15th October and at Brigg on the 20th October 1958.

The author is in the Department of Electrical Engineering at the University of Sheffield.

F. A. BENSON, D.ENG., PH.D., ASSOCIATE MEMBER

PHOTOCELLS may operate almost any kind of electrical or mechanical device through suitable amplifiers and relays. They may cause a device to react to almost any light-intensity variation and will respond to radiation in the visible, infra-red or ultraviolet parts of the spectrum.

The type of cell to be chosen for a particular application depends on many factors, e.g. the required sensitivity and the quantity of light available, matching of the spectral response of the cell to the emission of the source, and the spectral range of measurement.

Photometry

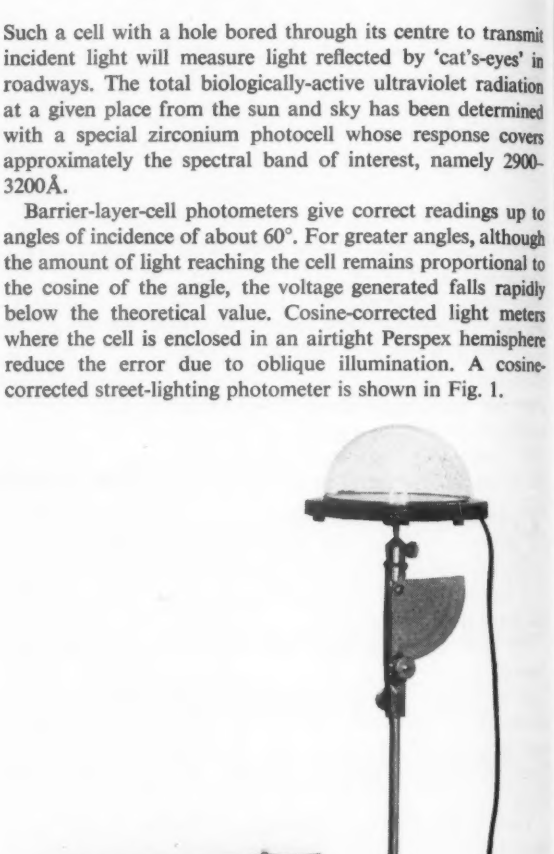
The objectives of photometry are well known. The unknown illumination is compared in some way with a known standard. Problems encountered in such measurements using photocells are variations in spectral response between cells even of the same type and lack of constancy of response and linearity of photocurrent with incident-light flux. Gas-filled cells are not well suited for the purpose but vacuum cells give reliable results if special precautions are taken.

When the spectral emissions of the standard and the unknown sources differ exact measurements cannot be obtained unless these emission characteristics and the photocell colour response are known. Faulty colour response can frequently be corrected by the use of suitable filters or a method whereby the light from the source is split into a spectrum and focused in the plane of a suitably shaped opaque template which intercepts a desired amount of light of each colour. The whole of the transmitted light is then collimated onto the photo-cathode.

Photocells for photometric work should have uniform sensitivity over the cathode surface in case the light spot moves about. A diffusing screen in front of the cell will eliminate small non-uniformities.

Portable barrier-layer-cell light meters mounted on extensible poles have been used to explore inaccessible places. Such a cell with a hole bored through its centre to transmit incident light will measure light reflected by 'cat's-eyes' in roadways. The total biologically-active ultraviolet radiation at a given place from the sun and sky has been determined with a special zirconium photocell whose response covers approximately the spectral band of interest, namely 2900–3200 Å.

Barrier-layer-cell photometers give correct readings up to angles of incidence of about 60°. For greater angles, although the amount of light reaching the cell remains proportional to the cosine of the angle, the voltage generated falls rapidly below the theoretical value. Cosine-corrected light meters where the cell is enclosed in an airtight Perspex hemisphere reduce the error due to oblique illumination. A cosine-corrected street-lighting photometer is shown in Fig. 1.



1 *Street-lighting photometer*

Spectrophotometry and astronomy

In spectrophotometry only the energy contained in a narrow band of the total spectral emission of the source is available; photocurrents are therefore very small and photomultipliers are used.

With their rapid response photoelectric spectrophotometers are useful for finding the spectral distribution of the light emitted during the decay time of phosphors or the spectral lines emitted at different phases of an arc discharge.

The spectral distributions of the luminescence of materials such as cloth samples have been obtained with ultraviolet excitation.

Only very small light energies are available in the fields of astronomic photometry and spectrophotometry. Photoemissive cells with electrometer valves have been used for such applications, and the measurement of light intensities from stars with photomultipliers at liquid-air temperature has been discussed. Colours of stars have been observed using colour filters and antimony–caesium surfaces.

Photoelectric methods have also been used to determine star positions, numbers and sizes; and photomultipliers are available for such purposes.

One particular application of the photomultiplier in astronomical work is the position control of large telescopes. The problem is essentially that of guiding the telescope axis so that it remains directed towards one particular star or area of sky despite the earth's rotation which would produce misalignment if the telescope were not continuously corrected.

Radiation detection

The photomultiplier can detect and measure the intensity of radiation from radioactive sources. Radiations such as α-particles, electrons and γ-rays produce fluorescent light in certain substances; moreover when a particle or quantum strikes a fluorescent screen the conversion of the particle or quantum energy to light is almost complete and the intensity of the scintillation is a measure of the energy.

A photomultiplier will detect single radiation quanta or particles provided that the scintillation releases more photoelectrons than the number of 'dark-current' electrons emitted during the fluorescent response time of the screen. For example 5MeV α-particles have been observed to release about 10^4 electrons each, and the amplitude of the amplified photoelectric current pulse when displayed on a cathode-ray tube is about 50 times the background noise. Similarly 1·7MeV β-particles (electrons) give pulse heights of about 10 times the background noise, and single pulses from 25keV X-ray quanta can be distinguished above background noise.

Photomultiplier tubes combined with zinc sulphide phosphors are employed in portable probes for monitoring workbenches and clothing for α-particle contamination. Measurement of corpuscular radiation and X-rays by photocells and construction of special tubes for detecting single particles have often been described.

Gamma-ray spectroscopy is one of the most elegant techniques in the scintillation-counter field. Thallium-activated sodium iodide is a particularly important material for γ-ray detection.

Recording of transient optical phenomena

In recording transient optical phenomena such as electrical discharges, lightning and light outputs from photoflash tubes, the problem is essentially the presentation of the intensity variations of the source as a function of time on an oscillograph. The photomultiplier is used for converting the optical transient to an electrical transient which can then be presented on the cathode-ray-tube screen in a conventional manner. In many cases the transient is a single event the duration of which may be between wide limits, say 10^{-1} down to 10^{-8}sec.

Reflectometers

Photocells find various applications in the measurement of reflection and emission from and transmission through materials. Reflectometers for instance have been developed for rapidly comparing shades of camouflage paint, paper, plastics, rubber, leather and dyes. Some instruments measure specular and diffuse reflections and the ratio between them for a fixed angle of incidence and of reflection, and certain attachments enable the colour characteristics, transmission and sheen (specular reflection at large angles of incidence) to be determined.

Very sensitive instruments called comparators have been produced for measuring small differences in reflectance and are particularly suitable for off-white specimens. These are also ideally suited for laundry use and for determining the degree of bleaching, dyeing and fading of fabrics.

Fluorometers

A simple fluorometer has been produced for estimating the vitamin concentration in solutions. A high-pressure mercury arc emits two beams filtered to remove visible radiation, one beam then passing through the specimen under test and the other through a standard fluorescent substance. After passage through these materials the ultraviolet is removed and the visible-radiation beams fall on two photocells connected in opposition and to a galvanometer. From the galvanometer reading the concentration of the fluorescent material in the liquid can be found. Similar more-sensitive equipment has been developed for weakly fluorescent materials.

A closely related topic is the derivation of bacterial luminescence. The vitamin-A content of liquids can be determined by measuring the absorption of radiation of 3280Å wavelength, and the vitamin-A content of cod-liver oil has been continuously controlled. Photoelectric colorimetric methods have been used for finding colours of petroleum products and lubricating oils and determining engine wear by measuring the iron content of oil.

Detection of metals

If a metallic salt is introduced into a non-luminous flame it burns with a colour characteristic of the particular metal. The flame photometer makes use of this phenomenon to derive the relative concentrations of the alkali metals in solutions. The specimen is atomized and introduced into the flame which becomes coloured. The intensity of the light emitted is measured with a photocell. Such systems are widely

employed in agriculture for potash determinations and in the medical field for determining sodium and potassium in blood.

The photoelectric titrator is a simple instrument for carrying out any titration involving a colour change and has particular applications in the medical, agricultural and metallurgical fields for the determination of for example impurities in metals or calcium and magnesium in serum.

2 *Simple filter photometer for colorimetric analysis of water and wastes*

A more sensitive instrument for colour determination is the absorptiometer which is designed for weak concentrations or low turbidities. Absorptiometers are used in metallurgical laboratories for routine quality control of metals. Impurities are leached out of the materials to provide coloured solutions the concentrations of which are determined. The quantitative determination of nickel in iron and steel is commonly carried out in this way.

Tantalum and several other metals form red compounds of various intensities and hues with phenylfluorene, and the colour reaction has been made the basis of a method for the photometric determination of tantalum in a sample.* Traces of selenium and tellerium in lead or copper, antimony and thallium in lead, and sulphur in iron and steel have also been determined photoelectrically.*

Colorimetric analysis of liquids

Photometric instruments are frequently used for colorimetric analysis of water and wastes. The simplest types are known as filter photometers. White light focused to a parallel beam passes through a filter which absorbs all but the required colour (Fig. 2). A slit selects a narrow beam which is partly absorbed by the sample; the unabsorbed portion of the coloured beam falls on a photocell giving an output that is measured on the galvanometer. The light source is usually a tungsten-filament lamp operated either from accumulators or from a mains-fed constant-voltage transformer.

A serious problem with such a simple instrument is that of maintaining a constant intensity of the light source. This has led to two-cell arrangements such as that shown by the schematic of Fig. 3 where light fluctuations affect the two cells equally and are thus cancelled out. The light beam is split, one portion passing to a 'balancing' photocell and the other through the sample to the 'measuring' photocell. The galvanometer is used as a null meter, a variable resistor being employed to obtain the balance point.

A device (the alcometer) used by police to test for intoxication uses the photocell colour-response characteristic. The suspect breathes into a chamber containing iodine pentoxide which when contacted by alcohol releases iodine. The iodine is piped to a starch solution turning it blue. The more alcohol in the breath the bluer the starch as shown by the output of a photocell.

Turbidimeters

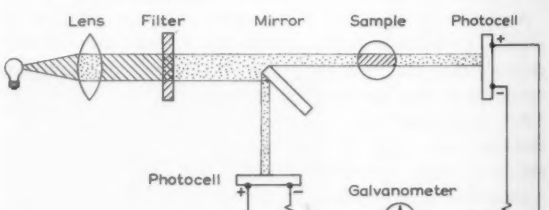
Turbidity, the presence of small particles of solid matter in liquid, can be measured by an arrangement where the solid matter causes scattering of a light beam. A similar system has been applied to determining the effectiveness of air filters where light scattered by the unfiltered air is made to fall on a photomultiplier and is compared with light scattered by filtered air.

The fineness of cement can be found by utilizing the scattering effect which the finely dispersed particles exercise on a light beam passing through a suspension of cement in castor oil or liquid paraffin.

Turbidimeters are used in the analysis and control of sewage and for observing the action of penicillin on staphylococci. Nephelometers for readily comparing turbid solutions are designed primarily for the examination of bacterial growth without removing the cultures from the test-tube in which they are incubated.

Photocells can also be used for observing films precipitated in the form of insoluble soaps on surfaces immersed in detergents, finding the scattering of monochromatic light as a function of the angle of scattering for solutions, measuring small differences in refractive indices of liquids and determining haemoglobin and chlorophyll contents of solutions. The water-vapour content of the atmosphere can be determined photoelectrically because water vapour strongly absorbs infra-red radiation of 9340Å. Poisonous gases can be detected by their strong absorption of certain ultraviolet wavelengths. A similar method can be used for detecting large concentrations of carbon disulphide gas.

3 *Two-cell instrument for colorimetric analysis that uses a balancing photocell to compensate for variations of light-source intensity*



Moisture content of steam can be determined by its transparency. Automatic chlorination of water is based on the detection of residual chlorine by the yellow to orange-red discoloration of an orthotoluidine reagent. Similarly mercury vapour can be detected by the discoloration of selenium sulphide, and ozone by its absorption of radiation of 3130Å wavelength. Water hardness and organic matter in sand filters for water purification can also be determined with the aid of photocells.

* Unpublished work carried out by C. L. Luke at the Bell Telephone Laboratories

Detection of infra-red radiation

Signals transmitted on infra-red beams can be detected with thallium sulphide or other photoconductive cells or by a photomultiplier or an image tube.

Lead sulphide photoconductive cells are efficient detectors of hot bodies such as aircraft-engine exhausts and ships' funnels and have been fitted in 'homing' bombs and rockets which home automatically onto hot parts of aircraft, ships, factories, etc. They have also been used for detecting radiation from filament lamps for infra-red telephony, in pyrometry and infra-red spectrometers, for measuring temperatures resulting from severe braking in moving vehicles, for detecting hot axle bearings and for monitoring gas, oil-fired and pulverized-fuel furnaces.

Changes in brain activity cause minute temperature variations in the scalp which can be detected as variations in radiated energy at a wavelength of 10μ by means of an instrument employing a lead sulphide cell. The device also has applications for aircraft collision warning since it can detect small changes of target temperature at large distances in clear weather.

Often the detection of an infra-red-emitting object is not sufficient but its shape must also be known. Image tubes can be used to convert infra-red images to visible ones. Emphasis in the development of infra-red equipment has been on military applications, but image tubes and infra-red telescopes can be used for detecting forgeries, for infra-red microscopy and for photographic purposes where visible light must be excluded. Devices such as the infra-red iconoscope have extended the wavelength range much further than the image-tube range.

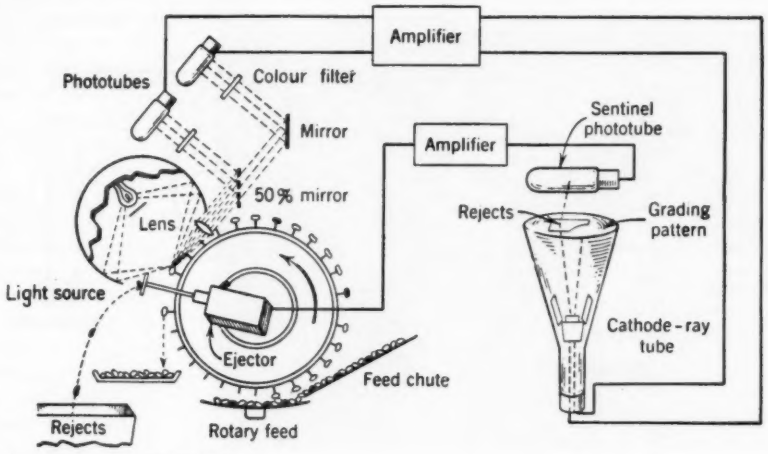
Smoke detection

Photoelectric equipment finds wide application in continuous automatic control of chemical and industrial processes in industry, for example for smoke and dust detection, observing colour and gloss of textiles, and observing colour of flue gases in flame-failure detectors. Smoke detectors are extensively used on ships and in air-conditioning systems of theatres.

In one aircraft smoke detector two selenium cells and a small lamp are arranged in a black box fitted with louvres to allow entrance of smoke. The output currents of the cells are fed in opposition to a relay. The smaller cell mounted behind an adjustable shutter is directly illuminated by the lamp while an intense light beam passes over the other larger cell without shining on it directly. Some stray light always reaches the larger cell, and the current generated by it is balanced out by adjusting the shutter over the smaller cell.

When smoke enters the box it obscures the light falling onto the small cell. At the same time the intense beam illuminates the smoke so that the large cell now receives a certain amount of scattered light.

The out-of-balance current which results operates the relay and alarm.



4 *Bean-sorting machine*

Photocells in production control

Uniform flow of liquid through pipes can be maintained photoelectrically. There are several photoelectric methods for cutting metal sheet with blow-torches from given patterns, controlling heavy machine tools, producing smooth-ended rolls in the paper industry, inspecting quality of machined surfaces, providing safety 'curtains' for machine operators, measuring thickness and width, determining the diameter and elastic properties of wire and checking the uniformity and strength of yarn.

Photoelectric devices are used for supervising automatic packing and for automatic inspection such as examining fruit and vegetables for quality, colour and size, checking for foreign particles in bottled drinks or packaged goods, detecting chipped or cracked bottles, inspecting surfaces for cracks, flaws or impurities, checking goods for missing items and measuring sugar content in beverages or concentration of syrups. Photocells find applications in automatic weighing and automatic sizing of spherical objects, e.g. steel balls and oranges.

Fig. 4 shows a bean-sorting machine which picks out off-colour beans. The beans are picked up singly from a chute and exposed to a light beam. The reflected light is directed by a half-silvered mirror onto a red-sensitive photocell with a red filter and then by a second mirror to a blue-sensitive photocell with a green filter. The cell outputs are applied to vertical and horizontal deflector plates of a cathode-ray tube, the colour and brightness of the bean being thus indicated by the position of the fluorescent spot on the tube screen. A mask covers the area of the screen which corresponds to acceptable-bean reflection characteristics. A third photocell in front of the cathode-ray tube receives light only when the

bean is off-colour and it then actuates a relay which rejects the bean.

Aids for the blind

Photoelectric guiding and reading aids have been produced for the blind. Fig. 5 shows a suggested reading machine which employs a siren disc with five or more rings of apertures so spaced as to interrupt the light from a linear source at frequencies corresponding to five musical notes. The disc is imaged through a slit in a selenium cell on a line of type on a printed page resting on a glass plate, the five modulated light spots falling on a line of the same height as the type perpendicular to the printed line.

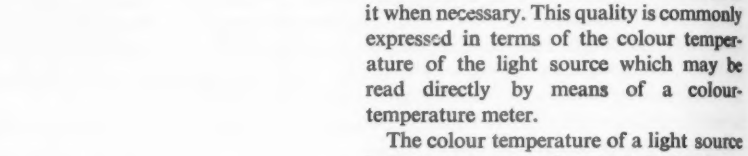
5 *Suggested reading machine for the blind*

The reflected light falls on the selenium cell which controls an earphone or loudspeaker. The nature of the sound emitted depends on the amount of black and white in the vertical section of a letter scanned by the light spots at any instant. As the pages are slowly moved parallel to the printed lines a series of characteristic sounds are emitted which the blind person can learn to identify as corresponding to different letters.

Other instruments have attempted to translate printed matter into raised type corresponding to Braille; here the output of the photocell is fed to circuits which actuate magnetic plungers to produce raised letters on thin aluminium sheets.

Fig. 6 shows a portable guiding device for the blind. The device projects a narrow beam of modulated light in the direction in which it is pointed. Depending on the distance of the object, reflected light falls on different sections of a 'coding cone' (a rotating perforated shutter) which imposes either a low-frequency modulation varying with distance or easily differentiated dot–dash signals. The transmitted light falls on the photocell whose output is amplified and fed to a hearing-aid amplifier. A blind person carrying the apparatus can rapidly determine the distance and extent of an obstacle by the musical notes emitted as the beam is swung to and fro.

6 *Guiding device for the blind*



Colour temperature

Objects appear different in colour when viewed under different types of illumination owing to the colour contributed to the object by the illuminant. In colour photography this is of prime importance since many types of colour film are processed to give correct colour balance only when exposed with a particular quality of lighting. It is therefore essential to be able to measure and express the quality of the illumination and to select filters to correct it when necessary. This quality is commonly expressed in terms of the colour temperature of the light source which may be read directly by means of a colour-temperature meter.

The colour temperature of a light source is the temperature of a 'black body' (i.e. a perfect radiator) which emits light of the same colour as that source and is usually expressed in degrees Kelvin. Colour temperature is therefore a measure of light quality and may bear no relationship to the actual temperature of the source. For example blue sky may have a colour temperature of 12000°K; this is not its temperature but is that to which a black body would have to be heated to emit light of the same colour.

Incandescent bodies are in general 'non-selective' radiators which means that the light emitted by them has a given colour composition independent of their nature and dependent solely on the temperature of the emitter. If the colour

composition of the light is known therefore, the temperature of the emitter is known also.

The temperature of a non-selective emitter can be determined by measuring the ratio between the red and blue contents of the light. Two photocells are situated side by side in a balance circuit similar to that in the smoke detector described above with the relay replaced by a centre-zero galvanometer. One cell is fitted with a red-glass and the other with a blue-glass filter. A shutter is arranged so that when rotated part of one cell–filter combination is progressively obscured and part of the other is progressively exposed to light.

To measure colour temperature the shutter is simply rotated to give no deflection on the galvanometer. With this shutter position the ratio of the exposed blue-cell area to the exposed red-cell area is inversely proportional to the ratio of the red-light intensity to the blue-light intensity. The instrument is calibrated empirically so that from an index on the shutter colour temperatures can be read directly.

A somewhat similar arrangement has often been used in the laboratory where the source is placed in an integrating sphere. Two windows are provided in the sphere, and the light flux through them is received by a red-sensitive and a blue-sensitive photocell respectively. The ratio of the photocurrents may be employed to determine the colour temperature of the source.

Electroluminescence

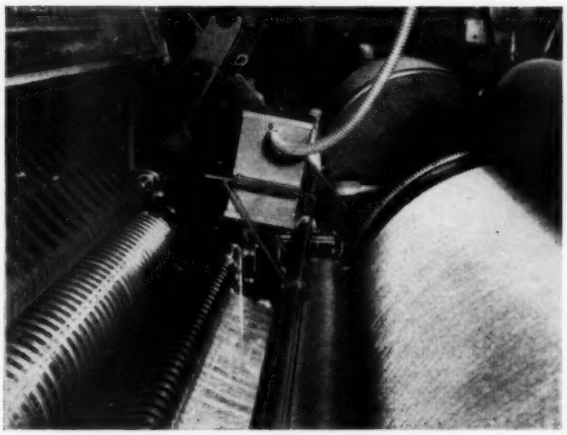
Great interest now centres on the use of electroluminescence in light or image amplifiers. In a specially constructed panel the intensity of a faint image caused by ultraviolet radiation on the phosphor layer may be amplified by applying a d.c. field to the panel. In another arrangement both conducting plates of the panel are transparent, and interposed between one of the conducting surfaces and the phosphor resin layer is an opaque photoconducting layer of cadmium sulphide.

In the dark the panel does not light up on applying alternating voltage since the cadmium sulphide layer is non-conducting. If a weak image is projected onto this it becomes conducting and the light pattern is reproduced in an amplified form on the electroluminescent surface.

By using two photocells, one in shunt with the electroluminescent panel and the other in series with the panel and first cell, a bistable element can be made by having optical feedback between the panel and the series cell. This can be developed to design devices in which switching is achieved optically. Recent experiments suggest that the cadmium sulphide cell should not yet be ruled out of consideration for high-speed operation.

Control of wool density

In producing woollen thread for weaving, the uniformity of the final thread depends largely on the weight/unit area of the web from which the thread is made. The density of the web produced on a wool-carding machine may be controlled photoelectrically. A unit housing the cell and a stabilized light source is mounted on the machine as illustrated in Fig. 7. The light is reflected back to the cell by a mirror situated below the web so that it passes through the web twice. The quantity of light falling on the cell therefore gives an indication of the wool density and can be used to control the latter by simply varying a gear ratio between two parts of the machine.



7 *Position of photoelectric unit on wool-carding machine*

Some miscellaneous applications

Other uses of photocells include burglar alarms, automatic opening of doors and control of artificial lighting, traffic counting, recording paths of vehicles, photography of fast-moving objects, measurement of time intervals, railway signalling, voltage stabilization, increasing accuracy of galvanometer readings, measurement of cloud height and depth, indication of pressure and liquid level, transmission of television programmes over beams of light, analysis by Raman spectra of hydrocarbon mixtures, and measurement of vibration and photographic exposure.

Many potted photocells are now built into 8 mm film cameras to adjust automatically the diaphragm when the camera is directed to the object of which a coloured moving picture is to be taken. Photocells are also widely used in acoustics, for example in sound reproduction. Interesting acoustical applications are the light siren and photoelectric organ. A large New York clothing firm uses a photoelectric method of measuring men for suits.

Photocells in electrophoresis apparatus measure proteins in body fluids, and photomultipliers are used in blood-cell counters. The effects of high-altitude flying on the oxygen content of the blood have been observed photoelectrically. The illuminating lamp is fixed on one side of the ear, and the amount of green light transmitted through the thin scapha membrane of the ear is measured by a photocell on the other side.

Photocell generator units have been constructed for supplying transistorized radio receivers directly or for charging small accumulators which are then used to operate transistorized receivers. In the latter case power can be stored for use during periods of low sunlight intensity.

Acknowledgments

The author wishes to acknowledge the kindness of the Illuminating Engineering Society in allowing him to use material from a paper entitled 'Characteristics and applications of photoelectric cells' published in the *Transactions of the I.E.S.*, 1958, vol. 23, p. 127, and of Dr. C. L. Luke of Bell Telephone Laboratories in providing details of unpublished work on photometric determination of traces of impurities in metals.

The author also thanks the following for giving him permission to reproduce illustrations:

Prof. J. C. Morris of Harvard University for Figs. 2 and 3 taken from 'The use of photometric instruments for colorimetric analysis of water and wastes', Harvard University Sanitary Engineering Reprint No. 19 (new series)

John Wiley and Sons for Figs. 4, 5 and 6 taken from 'Photoelectricity and its applications' by V. K. Zworykin and E. G. Ramberg; also the McGraw-Hill Publishing Co. and the Editor of *Electronics* for Figs. 4 and 6 and the Royal Society for Fig. 5

Summary

Photocells have found applications in almost every industry. Production processes formerly controlled by the visual sense of man, sometimes in dangerous conditions, are now open to fully automatic photoelectric control. The introduction of such control frequently increases output, ensures more uniform quality, enormously speeds up inspection, reduces production costs and minimizes waste.

Photoelectric devices are now available which will react to luminous, infra-red or ultraviolet radiation; and they respond in conditions which cannot be observed by human beings, or where an object is not suitable for mechanical or manual handling.

SETS conference 1959

THE third annual conference of the Scottish Electrical Training Scheme was held on the 24th September 1959. These conferences have been held each year during SETS's existence and are the only occasions on which all the trainees meet, collecting from their places of training all over Scotland; they have now been adopted as a permanent part of the training programme.

Nearly 100 trainees attended, the same number as last year, but those who had done pre-college training were this year excluded to keep down the numbers on the works visits. Of the total, 30 (11 last year) were graduates and the remainder men doing vacation training. As in previous years the trainees, who were accompanied by most of the directors of SETS and other representatives of its members, toured the factories of two of the members, spending half the day with each. This year two Lanarkshire members were selected, and the luncheon given to the trainees by the directors of SETS was held at Bothwell.

In a short speech after the lunch Mr. A. Christianson, Chairman of SETS, welcomed the trainees and thanked the two members. Mr. R. O. Welsh (graduate trainee, St. Andrews University) replied for the trainees.

Think ahead

Mr. J. E. C. McCandlish, Organising Secretary, said that last year SETS (then in the second year of its life) had been sure that it had made a satisfactory start; the position this year confirmed that view.

In 1959 three men had completed their graduate training and were now employed by three of the SETS members. Eleven men would similarly complete their training in 1960. In 1961 the figure would be doubled: 22 graduates had started their two-year course in 1959.

From 1962 onwards SETS would be working to its full target of about 25 graduates a year; what was also important was that in and after 1960 all or very nearly all its graduates would be men who had done vacation training in SETS. This policy of integrated vacation training had always been the intention of those who created SETS.

He repeated the advice given to trainees last year that the good engineer must be a man of wide interests and knowledge; university and graduate training periods were the times to develop a broad outlook. This year he wanted to impress on all trainees, particularly graduates, the importance of thinking ahead.

Before each phase of training they should make a list of the particular lessons they wished to learn from that phase; at the end of it their reports to him should include an appraisal of their success (or perhaps even of their failure) in learning those lessons.

NORMAL SERVICE WILL BE RESUMED . . .

EXTRACT from the *Journal*, 1889, **18**, p. 463.

Part of the discussion on a paper by Prof. Oliver Lodge, 'Lightning, lightning conductors, and lightning protectors', on the 9th May 1889.

Mr. J. Wimshurst (*discussing the behaviour of a spark in a negative cloud, when a point is then struck in preference to a dome*): . . . I purpose showing you first the conditions when there is little preference. We will turn the machine and show its polarity. [Machine does not act readily.] This machine is now nearly five years old; it has never yet hesitated as at the present moment.

Prof. Oliver Lodge: The failure of a Wimshurst machine is of itself a striking experiment.

The Chairman (Dr. J. Hopkinson): Would it be satisfactory to you, Mr. Wimshurst, if somebody else went on with the discussion while you are preparing your experiment?

Mr. J. Wimshurst: Yes; quite so.

621.365.39

Electrical floor-warming

Floor-warming is not a new system of space-heating, but it is a comparatively recent development in the electrical industry. Floor-warming by electrical cables is an attractive off-peak load to area boards; the low capital cost of an electrical system and the availability of low off-peak tariffs are the attractions for the customer. This article reviews the electrical floor-warming systems which are available and is based on part of the author's paper 'Space-heating by electricity' which he read at a meeting of the Irish Branch on the 20th November 1958. Mr. Walsh is with the Electricity Supply Board, Ireland.

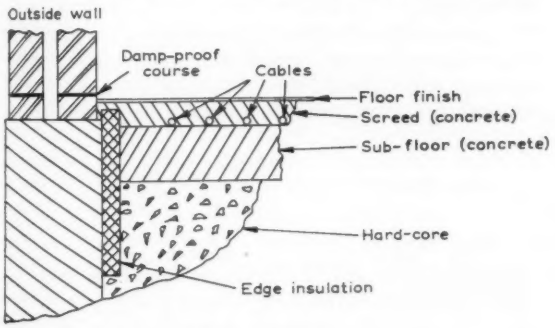
P. WALSH, B.E., ASSOCIATE MEMBER

IN the remains of some Roman villas one can still see the essential features of a floor-warming system; the floor was supported on piers and the hot gases and air from a central charcoal fire were ducted under the floor and exhausted to atmosphere through a flue built into a wall. We must assume that some Romans appreciated what is now an experimentally established fact—that ideally for comfort a person's feet should be slightly warmer than his head. This comfort condition can be achieved only if some or all of the space-heating requirements are met by floor-warming.

The first installations of electrical floor-warming used uninsulated conductors supplied at low voltage; the conductors were solidly embedded in the concrete floors. Many such installations were completed pre-war and are still operating satisfactorily. However considerable development in the field of electrical floor-warming did not take place until electricity area boards introduced attractive off-peak tariffs and suitable cables were manufactured for operation at normal mains voltage. Only in this sense can electrical floor-warming be considered a recent development.

Heating requirements

Floor-warming systems whether electrical or not can be designed to meet the full heating requirements of a building or to provide a background heat which can be 'topped up' by other means. The method of calculating heating requirements need not concern us here but it is important to realize that there is a limit to the amount of heat which may be drawn from the floor. Experiments have established certain maximum floor-surface temperatures which can be tolerated without discomfort. These are roughly 75° F where occupants may be standing for long periods or up to 80° F in halls or corridors.



1 *Section of a ground-floor system*

Since the heat emission from a warmed floor is roughly proportional to the temperature difference between floor surface and room air the allowable thermal load in the floor must be reduced as maintained air temperature is increased. For many buildings calculation will show that full comfort cannot be given by floor-warming alone without exceeding the maximum permissible floor-surface temperature in very cold weather. In such cases it is most important that the limitation of the system should be recognized and supplementary heating provided by other means.

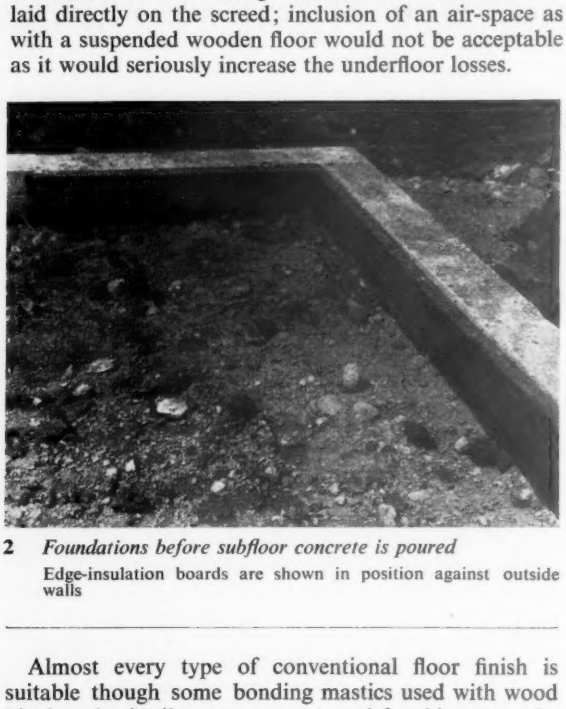
Floor structure

Electrical floor-warming is a system of heating primarily suited to new buildings, where the heating cables are generally laid in the floor slab when the building is under construction. However there are various methods of laying cable to give floor-warming with existing suspended wooden floors. The heating effect is then similar to that obtained with an electrically heated carpet underfelt—but obviously the system does not lend itself to off-peak operation.

An off-peak heating system must make use of a thermal-storage medium, and for electrical floor-warming this medium is the concrete floor. Fig. 1 shows a section through a floor containing heating cables. The cables are laid on the subfloor concrete and are covered by a concrete screed 2–3 in. thick. The section illustrated is of a ground floor, and thermal storage is provided by the screed, subfloor and—to a lesser extent—the hard-core filling. Since the whole floor slab is heated thermal-insulating boards of high insulating value must be laid at the outside edges to minimize heat losses. These are shown in position in Fig. 2.

Generally it is neither necessary nor advisable to provide insulation under the whole floor as appreciable

losses can occur only at the outside edges and complete underfloor insulation would eliminate the effectiveness of the hard core as a storage medium. The floor finish is laid directly on the screed; inclusion of an air-space as with a suspended wooden floor would not be acceptable as it would seriously increase the underfloor losses.



2 *Foundations before subfloor concrete is poured*
Edge-insulation boards are shown in position against outside walls

Almost every type of conventional floor finish is suitable though some bonding mastics used with wood blocks, plastic tiles, etc. are not, and for this reason the flooring contractor must always be informed that floor-warming is to be employed.

Floor-warming cables are also laid in solid-concrete intermediate floors. It may be necessary to fit thermal-insulating board below these floors if it is desirable to limit the heat losses from the floor slabs to the rooms below; alternatively the floor slab containing the heating cables may be floated on a glass-fibre quilt which will then act both as a thermal insulant and as a sound absorber.

Low-voltage systems

Though most electrical floor-warming systems are now of the mains-voltage type there are still many applications for low-voltage systems. While they have the disadvantage that the cost per kilowatt installed is comparatively high they have the advantages that most of the materials cost (principally transformer) is recoverable and that very low loading per circuit is possible. Economically it can generally be demonstrated that a low-voltage system is the correct one for installations of a temporary nature. It can also be used with advantage in factories for heating machine-tool plinths to provide a comfortable source of radiant heat for the operators.

Generally bare galvanized-steel or copper-alloy conductors are used. The system cannot normally be recommended for private houses as it is difficult to avoid transformer noise without considerable added cost.

Mains-voltage systems

These are of three types: withdrawable, in which the heating cables are laid in tubes or ducts in the floor and can be withdrawn in the event of fault; rewirable, in which the heating element can be withdrawn and replaced but its associated insulation is fixed; and embedded, in which the cable and insulation are solidly embedded in the concrete screed.

Withdrawable

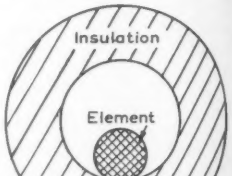
Systems of this type have 2–3in.-deep troughs which are laid on the subfloor at opposite ends of the space to be heated before screeding is commenced. D-shaped or circular metal ducts (sectional area roughly the same as $\frac{5}{8}$in. conduit) are spaced at about 9in. from trough to trough across the room, and the floor between troughs is then screeded. Later a lead-covered asbestos-insulated cable is drawn through the ducts, and terminal connections are made within the troughs. The cover plates are placed over the troughs, and the floor finish is applied.

Two manufacturers offer systems of this type, the only notable difference being that with one an expanded-metal mesh is laid across the complete duct assembly as a heat diffuser. The cables are readily accessible and withdrawable in the event of a subsequent fault. The only disadvantage is the high initial capital cost compared with that of other types.

There is an interesting system of this kind in which the ducts are formed in the screed by inflated tubes. After the screed has set the tubes are deflated and withdrawn leaving circular ducts at the required spacing for the heating cable.

Rewirable

One manufacturer markets a floor-warming system which retains some of the advantages of a withdrawable system but has a considerably lower installed cost. As in the withdrawable system troughs are laid at both ends of the area to be heated on the subfloor. The cable which is illustrated in Fig. 3 consists of a galvanized-steel or copper-alloy element in an oversize p.v.c. sheath, the internal diameter of the sheath being approximately twice the outside diameter of the element. This cable is laid across the floor from trough to trough, being positioned at the required spacing by slots in the trough faces (Fig. 4).



3 *Cross-section of rewirable-system cable in outsize p.v.c. sheath*

The unique feature of this system is that a section of faulty element can be replaced without disturbing the

floor finish even though the cable is not laid in ducts. If a fault develops in the cable element the cable can be cut within the troughs at the appropriate end loops and the faulty-element section removed. Owing to the oversize nature of the p.v.c. insulating sheath a replacement section of element can be pushed through comparatively easily. The replacement section is then crimp-jointed into circuit and the joints are taped over.

Embedded

In a floor-warming system of the embedded type the cables are laid on the subfloor in accordance with predetermined design and the joints to supply cables are made. The heating cable and joints are then completely covered by screed so that the whole heating system is solidly embedded. The advantages of the embedded type are cheapness in first cost and undisfigured floor finish; the disadvantage is that the floor finish must be disturbed in the event of a fault.

Either mineral-insulated copper-covered or the now large range of plastic-insulated floor-warming cables can be employed.

Copper-covered cables with either copper or copper-alloy conductors are used, those with copper-alloy conductors being suitable for low-load circuits (less than 1 kW per circuit can be obtained). With this type of cable the copper sheath is held at earth potential and so forms an earthed screen; this is an advantage from the safety viewpoint.

A number of manufacturers now market plastic-insulated floor-warming cable. Since every manufacturer offers a range to suit different load requirements there is a very large total range to choose from. Over 50 plastic-insulated cables are now manufactured in Great Britain giving loads per circuit varying from less than 0·2 kW to more than 3·0 kW. One manufacturer can supply the cables with an earth screen consisting of an open braid of tinned-copper wire. An advantage of plastic-insulated cables is that owing to the elasticity of the insulation the cables are unaffected by minor building movement which may occur at expansion or construction joints in the floor.

Fault location

An article was published recently describing the highly accurate methods of cable-fault location which have been developed by the Midlands Electricity Board for all types of solidly embedded heating cable. Experience in these methods has developed the technique to such an extent that it can now be claimed that in the majority of cases it is possible to locate a fault to within $\frac{1}{4}$ in. on any size floor and under any type of finish.

For plastic-insulated cable with faulting to earth an induction test has been developed whereby the magnetic field set up by a signal current at up to 10 kc/s fed in at one end is detected by a search coil on the floor surface. The signal ceases at the point of fault. In the case of open-circuit of the element without damage to the insulation the fault can be located by tracing the magnetic field set up by the capacitance current produced by the application of a high-frequency voltage (about 1 kc/s, 1 kV) between core and earth.

For m.i.c.c. cables the first step in fault location is to map the cable lay-out by the induction method. All faults other than a short-circuit between core and sheath can be located by finding a 'hot spot' by hand or thermistor bridge circuit when a minute 50 c/s arc is created at the fault position, the power fed into this arc being limited to about 60–70 W. For very-low-resistance

4 *View of trough assembly of rewirable system*

short-circuits between core and sheath the induction test can be used by injecting the test signal between core and sheath. The fault position is then indicated by a sharp falling off in signal strength.

Automatic control

The systems employed to control the charge in electrical floor-warming installations are similar to those used with block-storage heaters. For control of small installations or of individual rooms of large installations a room-air thermostat is quite satisfactory. If the installation is intended to provide only background heating the controlling air thermostat must not be installed where auxiliary heating may be on during the charging period; maintenance of a high air temperature by the auxiliary heating will cause the air thermostat to prevent charging.

For larger installations a system combining the use of both indoor and outdoor air thermostats has been developed. This automatically increases the charging time of an installation in periods of cold weather and reduces it in mild weather. Tests have shown that the system works perfectly satisfactorily, and very successful results have been achieved in practice.

Another useful control system has the unique feature that the charge is automatically confined to the later hours of the charging period. Essentially it is a temperature-sensitive time switch, the time at which its contacts close or open being determined by outside temperature in accordance with a prearranged characteristic. Suppose an installation is designed for a full nine-hour charge from 11 p.m. to 8 a.m. to maintain 60° F indoor temperature with an outdoor temperature of 30° F. If the actual outdoor temperature is 45° F one-half full charge is required, and this control system will give the charge from 3.30 a.m. to 8 a.m.

It is advisable to include a floor thermostat in floor-warming installations—principally as a form of back-up protection to the main thermostatic control. If the maximum permissible floor-surface temperature is exceeded the room cannot be occupied without discomfort for some hours after completion of charge—this can happen in mild weather if the air thermostat sticks closed or is tampered with. A floor thermostat in series with the contactor coil, or directly in circuit in the case of a small installation, can interrupt supply if the floor-surface temperature exceeds 75° F.

Choice of system

If it is decided to install electrical floor-warming a choice must be made between the alternative systems which are available. The factors of cost, reliability, convenience and finished appearance must all be taken into account in the appraisal, and no single system can be universally recommended.

The withdrawable systems are not recommended for very small installations, but in large installations the greater reliability of these systems may counterbalance the higher initial cost. The point to be considered about the rewirable system is that it gives some of the reliability advantages of the withdrawable systems at a lower initial cost. Embedded systems are the cheapest in initial cost and result in a completely clear floor finish, but this finish must be disturbed if a fault develops.

Summary

Though there is still some doubt whether on-peak electrical heating can be supplied economically at present rates of charge, off-peak heating such as floor-warming is a useful method of improving the system load-factor. Development of this load will continue to be encouraged by area boards, and at present rates of charge it is an economical method of obtaining continuous space-heating. There may be increasing use of the solidly embedded systems in view of the development of reliable fault-location techniques.

A.E.A.'s THERMONUCLEAR PROJECT

THE United Kingdom Atomic Energy Authority are seeking the necessary approvals to acquire and develop a site of some 175 acres within the perimeter of the Royal Naval Airfield at Culham, Oxfordshire, for development as a new research establishment.

The new establishment would be for research into controlled thermonuclear reactions and plasma physics and the study of nuclear fusion as a possible source of industrial power. Most of the thermonuclear research now carried on at Harwell and Aldermaston will be moved to the new establishment.

Just over a year ago the authority decided that the controlled thermonuclear project should be moved from the Atomic Energy Research Establishment at Harwell because Harwell was becoming too large for convenient management. It was originally thought that a suitable location would be the new research establishment then being developed at Winfrith Heath in Dorset.

On reconsideration it was decided that because the project will for some years be concerned with basic studies preference should be given to a site nearer the A.E.R.E. and the National Institute for Nuclear Research (both at Harwell) and to Oxford University. Culham was found to be the best site of adequate size and with the necessary good communications to meet this requirement.

One of the immediate tasks at the new site would be the construction of I.C.S.E. (Intermediate-Current Stability Experiments), a machine which will incorporate the results of experience with Zeta and of other studies in this field both at home and abroad.

200MW TURBOGENERATORS

ON the 15th October 1959 the most powerful turbo-generator in Britain was switched into service at High Marnham power station, near Retford, Nottinghamshire. With a capacity of 200 MW it is believed to be the most powerful in Europe. Its output is sufficient to supply the demand of a city the size of Leicester.

The machine is the first of five which will be erected at High Marnham, and when all are working the station will have a capacity of 1000 MW, twice that of the present Battersea power station. When in full operation High Marnham will consume over 9000 tons of coal per day.

The main civil engineering works of this station were started in 1956, and construction of the generating plant began a year later. A labour force of up to 1800 men has been engaged on the site.

The development of more powerful generating sets by the Central Electricity Generating Board is resulting in considerable economies. The over-all dimensions of these large sets have not increased proportionately with output which means that power-station buildings accommodate more plant capacity per unit volume than those built ten years ago. The older stations averaged 50 ft^3/kW (installed) compared with new stations with as little as 28 ft^3/kW.

Big economies are therefore possible in the design and construction of power stations housing these more powerful sets with their associated boilers. Power stations today are being constructed at approximately the same cost (£50 per kilowatt installed) as in 1948 despite a 70% increase in the cost of materials and labour.

CHANGES IN THE BYE-LAWS OF THE INSTITUTION

As recorded in the May 1959 *Journal*, p. 279, a Special General Meeting of Corporate members of The Institution at Savoy Place on the 9th April 1959 approved certain Bye-law changes for submission to the Privy Council. A condensed account of the meeting will be found on p. 645.

The Privy Council have now allowed the changes, the details of which are set out in the Table below.

Copies of the amended Bye-laws may be obtained from the Secretary of The Institution on request.

Details of the amendments in the Bye-laws

ITEM	PREVIOUS BYE-LAW *Portions marked [ ] have been deleted*	REVISED BYE-LAW *Portions shown in* **bold roman type** *have been inserted*	EXPLANATORY NOTES
A	***DEFINITIONS AND SPECIAL PROVISIONS***		
	1. In these Bye-laws except where the context forbids words importing males are intended to include females and words implying the singular number are intended to include the plural number, and *vice versa.* 'The Institution' means The Institution of Electrical Engineers incorporated by Royal Charter dated 15th August, 1921. 'The predecessors of The Institution' means The Institution of Electrical Engineers incorporated under the Companies Acts, 1862 and 1867. 'The Charter' means the Royal Charter of The Institution dated 15th August, 1921, and any supplemental or other Charter for the time being in force and affecting The Institution. 'Abroad' means outside Great Britain, Northern Ireland, the Isle of Man, and the Channel Islands. 'The Institution Examination' means the examination [prescribed pursuant to Bye-law 67 for the purpose of testing the qualifications of candidates for election or transfer to the class of Graduates and to the class of Associate Members.]	1. In these Bye-laws except where the context forbids words importing males are intended to include females and words implying the singular number are intended to include the plural number, and *vice versa.* 'The Institution' means The Institution of Electrical Engineers incorporated by Royal Charter dated 15th August, 1921. 'The predecessors of The Institution' means The Institution of Electrical Engineers incorporated under the Companies Acts, 1862 and 1867. 'The Charter' means the Royal Charter of The Institution dated 15th August, 1921, and any supplemental or other Charter for the time being in force and affecting The Institution. 'Abroad' means outside Great Britain, Northern Ireland, the Isle of Man, and the Channel Islands. **'The Examination Regulations' means the regulations made by the Council pursuant to Bye-law 67 (c)(i).** **'The Training Regulations' means the regulations made by the Council pursuant to Bye-law 67 (c)(ii).** 'The Institution Examination' means the examination **bearing that name which is prescribed in the Examination Regulations.**	To accord with the revision of Bye-laws 12, 15 and 67
B	***MEMBERSHIP***		
	3. The Institution shall consist of: Honorary Members Members Associate Members Companions Associates Graduates Students Of the above [(i)] Honorary Members, who, when elected Honorary Members, were already [Corporate Members,] [(ii)] Members, and [(iii)] Associate Members shall be known as Corporate Members, and all others shall be known as non-Corporate Members	3. The Institution shall consist of: Honorary Members Members Associate Members Companions Associates Graduates Students Of the above (a) Honorary Members, who, when elected Honorary Members, were already **Members or Associate Members** (b) Members, and (c) Associate Members shall be known as Corporate Members, and all others shall be known as non-Corporate Members.	For greater clarity
C	6. No Honorary Member not being a Corporate Member, Associate Member, Companion, Associate, Graduate, or Student shall, by reason of being a member of The Institution, be entitled to any rights or privileges other than those which, by	6. No Honorary Member not being a Corporate Member, **and no** Associate Member, Companion, Associate, Graduate, or Student shall, by reason of being a member of The Institution, be entitled to any rights or privileges other than those which, by	For greater clarity

ITEM	PREVIOUS BYE-LAW *Portions marked [ ] have been deleted*	REVISED BYE-LAW *Portions shown in* **bold roman** *type have been inserted*	EXPLANATORY NOTES
	these Bye-laws, attach to the specific class of members of The Institution to which he belongs, and wherever the term 'Member' is herein used without qualification, it shall (except where otherwise expressly mentioned) be taken to exclude such Honorary Members as are not Corporate Members, Associate Members, Companions, Associates, Graduates, and Students.	these Bye-laws, attach to the specific class of members of The Institution to which he belongs, and wherever the term 'Member' is herein used without qualification, it shall (except where otherwise expressly mentioned) be taken to exclude such Honorary Members as are not Corporate Members, Associate Members, Companions, Associates, Graduates, and Students.	
D	***MEMBERS***		
	11. Every candidate for election or transfer to the class of Members [shall have been an Associate Member of The Institution for at least three years (unless in special cases the Council decide otherwise). He shall be at least 30 years of age and he] shall satisfy the Council either (a) that he— (i) [has been regularly educated and trained as an electrical engineer and satisfies the requirements of Bye-law 12;] and (ii) has had [subsequent] experience involving superior responsibility for at least five years in the applications of electricity; and he is, disregarding temporary unemployment [at the time of his application], engaged in or associated with any branch of engineering; or (b) that he— (i) has such knowledge of electrical science and has acquired such eminence in his profession that his admission as a Member would in the opinion of the Council conduce to the interests of The Institution; and (ii) is engaged in the practice of electrical science or engineering.	11. Every candidate for election or transfer to the class of Members shall satisfy the Council either (a) that he (i) **is at least 33 years of age and has been an Associate Member of The Institution for a period of at least three years or such lesser age or shorter period as the Council may in any particular case or class of cases decide, provided that in the case of a candidate who possesses the qualifications for election to Associate Membership, the Council may waive the stipulation as to his having been an Associate Member;** and (ii) has had experience involving superior responsibility for at least five years in the applications of electricity; and he is, disregarding temporary unemployment, engaged in or associated with any branch of engineering; or (b) that he— (i) has such knowledge of electrical science and has acquired such eminence in his profession that his admission as a Member would in the opinion of the Council conduce to the interests of The Institution; and (ii) is engaged in the practice of electrical science or engineering.	This change reflects more closely the lower age limit at which candidates are admitted to membership; the Council's discretion in respect of period of Associate Membership is preserved and is extended to apply also to the age of admission to the class of Members For brevity
E	***ASSOCIATE MEMBERS***		
	12. Every candidate for election or transfer to the class of Associate Members shall satisfy the Council either— (a) that he is at least 26 years of age, and (i) [has received a general education of a standard approved by the Council, and has been educated as an electrical engineer in a manner approved by the Council, and either possesses an educational qualification in electrical engineering approved by the Council, or has passed the Institution Examination;] and (ii) [has undergone practical training of an approved form of from two to five years according to the manner of his education as an electrical engineer; provided that in special circumstances experience in a responsible position as an electrical engineer may be accepted as approved practical training;] and (iii) has had not less than two years' experience in a responsible position as an electrical engineer in addition to any such experience which[, exceptionally,] may have been accepted [as practical training;] and the aggregate of his engineering education, [practical] training and responsible	12. Every candidate for election or transfer to the class of Associate Members shall satisfy the Council either— (a) that he is at least 26 years of age, and (i) **has attained a standard of general education and has received further education as an electrical engineer which satisfy the requirements of the Examination Regulations;** and (ii) **has undergone training which satisfies the requirements of the Training Regulations;** and (iii) has had not less than two years' experience in a responsible position as an electrical engineer in addition to any such experience which may have been accepted **in satisfaction of (ii) above;** and the aggregate of his engineering education, training and responsible experience is not less than seven years; and he is, disregarding temporary unemployment, engaged in or associated with any branch of engineering; or, **if he has not been educated as an electrical engineer,** (b) that he is at least 28 years of age, and	For greater clarity and to enable the Council, by reviewing their Regulations from time to time, to keep the requirements as to examination and training in accord with current needs

ITEM	PREVIOUS BYE-LAW *Portions marked [ ] have been deleted*	REVISED BYE-LAW *Portions shown in* **bold roman type** *have been inserted*	EXPLANATORY NOTES
	experience is not less than seven years; and he is, disregarding temporary unemployment [at the time of his application], engaged in or associated with any branch of engineering; or (b) [if not educated as aforesaid] that he is at least 28 years of age, and (i) [has received a general education acceptable to the Council and also either possesses a higher educational qualification approved by the Council or has passed the Institution Examination;] and (ii) [has undergone practical training of an approved form for not less than two years; provided that in special circumstances experience in a responsible position as an electrical engineer may be accepted as approved practical training;] and (iii) has had at least three years' experience in a responsible position as an electrical engineer in addition to any such experience which[, exceptionally,] may have been accepted [as practical training;] and he is, disregarding temporary unemployment [at the time of his application], engaged in or associated with any branch of engineering. The Council may require any candidate to attend an interview conducted on their behalf in order that he may the better satisfy them that he possesses the requisite qualifications.	(i) **has attained such a standard of general education and possesses such higher qualifications as satisfy the requirements of the Examination Regulations**; and (ii) **has undergone such training as shall satisfy the requirements of the Training Regulations**; and (iii) has had at least three years' experience in a responsible position as an electrical engineer in addition to any such experience which may have been accepted **in satisfaction of (ii) above**; and he is, disregarding temporary unemployment, engaged in or associated with any branch of engineering. The Council may require any candidate to attend an interview conducted on their behalf in order that he may the better satisfy them that he possesses the requisite qualifications.	For consistency of drafting
F	*ASSOCIATES* 14. Every candidate for election or transfer to the class of Associates shall be of good education and shall satisfy the Council that he is at least [28] years of age, that he has had at least five years' experience in a responsible position as an electrical engineer and that, disregarding temporary unemployment [at the time of his application], he is engaged in or associated with any branch of engineering.	14. Every candidate for election or transfer to the class of Associates shall be of good education and shall satisfy the Council that he is at least **30** years of age, that he has had at least five years' experience in a responsible position as an electrical engineer and that, disregarding temporary unemployment, he is engaged in or associated with any branch of engineering.	The change accords more closely with the age limit at which candidates are admitted to this class For consistency of drafting
G	*GRADUATES* 15. Every candidate for election or transfer to the class of Graduates shall have attained the age of 21 years but not the age of 35 years and shall satisfy the Council— (a) [that he has passed the Institution Examination or possesses an educational qualification approved by the Council for the purposes of this Bye-law], and (b) [either (i) that he has followed for not less than three years a regular course of higher education approved by the Council for the purposes of this Bye-law, which, if a part-time or 'sandwich' course of higher education, was undertaken while he was concurrently engaged in an apprenticeship or in other practical engineering work approved by the Council for the purposes of this Bye-law; or	15. Every candidate for election or transfer to the class of Graduates shall have attained the age of 21 years but not the age of 35 years and shall satisfy the Council— (a) **that he has attained such a standard of general education and has received such further education as satisfy the requirements of the Examination Regulations**; and (b) **that it is his intention in due time to seek Corporate Membership.** Unless the Council decide otherwise in any particular case or class of cases a Graduate shall cease to be a member of The Institution at the end of the calendar year in which he attains the age of 40 years. Until the end of the calendar year in which he attains the age of 28 years, a Graduate shall be entitled to the same privileges as a	The change establishes that admission to the class of Graduates is limited to those candidates who intend to qualify as Corporate members and are taking appropriate steps to that end For consistency of drafting

ITEM	PREVIOUS BYE-LAW *Portions marked [ ] have been deleted*	PROPOSED REVISED BYE-LAW *Portions shown in* **bold roman type** *are to be inserted*	EXPLANATORY NOTES
	(ii) that he has been a Student of The Institution for not less than three years.] Unless the Council decide otherwise in any particular case or class of [case] a Graduate shall cease to be a member of The Institution at the end of the calendar year in which he attains the age of 40 years. Until the end of the calendar year in which he attains the age of 28 years, a Graduate shall be entitled to the same privileges as a Student, and thereafter to such privileges, and for such period, as the Council may prescribe.	Student, and thereafter to such privileges, and for such period, as the Council may prescribe.	
H	***STUDENTS*** 16. Every candidate for election to the class of Students shall have attained the age of 17 years, but not the age of 28 years, and shall satisfy the Council— (a) that he is undergoing a regular course of [higher] education approved by the Council for the purposes of this Bye-law, and (b) that he has passed a preliminary qualifying examination approved by the Council for the purposes of this Bye-law except that the Council may defer the candidate's presentation of evidence of having passed such examination for such period as they may decide, which shall not extend beyond the end of the year in which he attains the age of 23 years, and (c) that he intends to satisfy the requirements for admission to the class of Graduates.	16. Every candidate for election to the class of Students shall have attained the age of 17 years, but not the age of 28 years, and shall satisfy the Council— (a) that he is undergoing a regular course of **further** education approved by the Council for the purposes of this Bye-law, and (b) that he has passed a preliminary qualifying examination approved by the Council for the purposes of this Bye-law except that the Council may defer the candidate's presentation of evidence of having passed such examination for such period as they may decide, which shall not extend beyond the end of the year in which he attains the age of 23 years, and (c) that he intends to satisfy the requirements for admission to the class of Graduates.	For consistency of drafting
I	17. Every candidate for election to the class of Students, who in complying with the requirements of Bye-law 16 follows an approved part-time or 'sandwich' course of [higher] education, shall satisfy the Council that he is concurrently engaged in an apprenticeship or [in other practical engineering work approved by the Council for the purposes of this Bye-law].	17. Every candidate for election to the class of Students, who in complying with the requirements of Bye-law 16 follows an approved part-time or 'sandwich' course of **further** education, shall satisfy the Council that he is concurrently engaged in an apprenticeship or **other engineering work which in either case, if duly completed, will enable him to satisfy the requirements of the Training Regulations.**	For consistency of drafting To accord with the revision of Bye-laws 1, 12 and 67
L	39. The Council may re-admit to membership in the class to which he formerly belonged any person whose membership has terminated from any cause provided he satisfies the Council that he is worthy of re-admission and pays such amounts in respect of entrance fee and arrears of subscriptions as the Council may determine.	39. The Council may re-admit to membership in the class to which he formerly belonged any person whose membership has terminated from any cause provided he satisfies the Council that he is worthy of re-admission and pays such amounts in respect of entrance fee and arrears of subscriptions as the Council may determine. **In the event of the Council deciding to refuse re-admission in any particular case, they may do so without assigning any reason.**	To correspond with the provision of Bye-law 21
M	58. At any meeting of the Council, each member of Council present [shall have one vote, save that of the Past-Presidents only the three who have last held the office of President, and any other Past-President who is at the time serving on any such Committee or Committees of the Council as the Council shall from time to time determine, shall be competent to vote. The Chairman shall have a casting vote.] The Chairman may direct, or any two members present may	58. At any meeting of the Council, each member of Council present **shall, save as hereinafter mentioned, have one vote and the Chairman shall have a casting vote. Of the Past-Presidents, only the three who have last held the office of President, and any other Past-President who is at the time serving on any such Committee or Committees of the Council as the Council shall from time to time determine, shall be competent to vote. At any meeting of the Council at which both the**	A reversion to previous practice in respect of the voting of Chairmen and Past-Chairmen of Local Centres

ITEM	PREVIOUS BYE-LAW *Portions marked [ ] have been deleted*	REVISED BYE-LAW *Portions shown in* **bold roman type** *have been inserted*	EXPLANATORY NOTES
	demand, that the voting shall be by a secret ballot.	**Chairman of a Local Centre and the Immediate Past-Chairman of such Local Centre or the Past-Chairman elected in his place under the provisions of Bye-law 44 shall be present, it shall not be competent for such Immediate Past-Chairman, or such Past-Chairman so elected, to vote.** The Chairman may direct, and any two members present may demand, that the voting shall be by a secret ballot.	
N	67. The Council may at any time cause examinations to be held for the purpose of testing the qualifications of candidates for election or transfer [and may require any candidate for election or transfer to any class of membership to attend an interview conducted on their behalf in order that he may the better satisfy them that he possesses the requisite qualifications. The Council shall from time to time define the subjects to be comprised in such examinations, and shall fix the fees to be paid or deposited by candidates for examination or interview.]	67. **(a)** The Council may at any time cause examinations to be held for the purpose of testing the qualifications of candidates for election or transfer **to any class of membership and shall from time to time define the subjects to be comprised in such examinations and shall fix the fees to be paid or deposited by candidates for examination.** **(b) The Council may require any candidate for election or transfer to any class of membership to attend an interview conducted on their behalf in order that he may the better satisfy them that he possesses the requisite qualifications, and shall fix the fees to be paid or deposited by candidates for interview.** **(c) The Council may make, vary and rescind regulations for all or any of the following purposes, subject always to the provisions of the Charter and Bye-laws for the time being in force:** **(i) To establish by examination or otherwise the educational requirements to be satisfied by candidates for election, or transfer, to any class of membership.** **(ii) To establish the training requirements to be satisfied by candidates for election, or transfer, to any class of membership.**	To accord with Bye-laws 1, 12 and 15. This change enables the Council to keep the requirements as to examination and training in accord with current needs

Special General Meetings on the 9th April, 25th June and 18th August 1959

9th April 1959 at Savoy Place (Corporate members only)

Mr. S. E. Goodall, President, took the chair at 5.30 p.m. He said that the alterations to the Bye-laws proposed by the Council which were the purpose of the meeting had sprung from the desirability of changes in membership requirements and the need to review entrance fees and annual subscriptions. The reasons for each alteration were briefly given in the Schedule to the Notice of the meeting. He moved and **Sir Willis Jackson** seconded that the Bye-laws of The Institution be altered in the manner set out in the Schedule.

There was no comment on items A, B and C (definitions and special provisions and membership—Bye-laws 1, 3 and 6). After an explanation of the purport of item D (Members—Bye-law 11) the President observed that within item E (Associate Members—Bye-law 12) they introduced a new departure by making reference to Training Regulations. In reply to questions he said that the Council intended to exercise their discretion in assessing a form of training that had not followed the normal pattern; and that men who had not served a graduate apprenticeship would not be excluded.

Amendments to the Schedule proposed by the President and by **Dr. P. A. Lindsay** were passed. Their effect was: delete 'exceptionally' from 12(a)(iii) and (b)(iii); delete 'practical' from 12(a); and substitute in 12(b)(iii) 'in satisfaction of (ii) above' for 'as practical training'.

There were no comments on item F (Associates—Bye-law 14). On item G (Graduates—Bye-law 15) there was a discussion of the words 'and that the work upon which he is engaged is conducive to this end' in 15(b). Some members felt it would be a pity to exclude recruits to The Institution merely because the work on which they were engaged was not so conducive, and on the motion of **Mr. E. L. E. Pawley** the meeting decided to delete these words from the Schedule.

There were no comments on items H and I (Students—Bye-laws 16 and 17). Items J (entrance fees—Bye-law 26) and K (annual subscriptions—Bye-law 27) were after some discussion considered together.

Mr. F. L. Coombs wanted a referendum of the membership on items J and K, but it was explained that there was no provision for this in the Bye-laws.

Mr. N. Dudley asked that the items be referred back to the Council with a request for forward estimates for a few years to give members an opportunity to assess the need for an increase in subscriptions of about 30%.

The President said the accounts for 1958 showed an income excess of only £5000, without any contribution to the Building

Fund. Over the past ten years the Building Fund had been milked of £69000, and that had to stop. For 1959 the forecast surplus was half that in 1958—less than 1% of revenue—and costs were still rising. He instanced that in 1956–57 there was an imposed increase of £13000 in postage and £4000 in printing. The Building Fund would cover over half the cost of the reconstruction at Savoy Place. Not only had they to finance the remainder (which they proposed to do on extremely favourable terms from the bank on a short-term basis) but they ought to replace the Fund.

The President's slides showed the decline in the value of £100 in 1938 to £36 in 1959 and the subscription rates for Associate Members since 1913. He averred that these data indicated sensible husbandry by The Institution.

Mr. Coombs felt items J and K should be rejected for these reasons: (i) the meeting was too small; (ii) it was wrong to take part in an inflationary move; (iii) the present subscription was sufficient; and (iv) The Institution should go in for an anti-Parkinson's law theory with its employees. It should reduce its expenditure, deal with inflation itself and set a good example.

Mr. G. S. C. Lucas, Chairman of the Finance Committee, pointed out that in face of a devaluation of 3 to 1, subscriptions had increased only 2 to 1. He was disappointed at the implied criticism that the committee did not watch every penny of expenditure.

Mr. P. W. Gatter thought it was a case of too much money and too little information. Any increase should be spread over the next five years.

Dr. Lindsay remarked that other institutions had lower subscriptions. He criticized the continuous and wasteful changes in *Journal* cover design culminating in a disagreeable and vulgar example. The building reconstruction would architecturally be a constant disgrace to The Institution.

Mr. C. T. Melling, Chairman of the Papers Committee, said that the activity of The Institution was incomparably greater than that 20 or 30 years ago, all at the request of the membership. The work involved was heavy, and a great deal of it was done by the staff of The Institution outside normal hours. Their life was rather hard compared with many others.

Mr. P. N. Wyke estimated that the increases asked for would produce £50000 or £60000 more a year, enough to pay off the deficit on the reconstruction in three years. It was abnormal to pay off capital expenditure in three years. It was time they followed fashion and set up a panel to go through the workings of The Institution to decide if it was efficient.

The President replied that that was the function of the Finance Committee who were extremely strict in approving expenditure. Each year the membership grew but so did the activities. One engineering institution with higher entrance fees and annual subscriptions conducted 32 meetings in London and 121 in the Provinces compared with The Institution's 122 in London and 704 in the Provincial Centres.

Mr. C. J. O. Garrard spoke as a recent ex-member of the Finance Committee. In business he had had to deal with finance and budgeting for many years. He had been on joining the committee quite prepared to be critical. He could say perfectly honestly that the procedure for budgeting and controlling expenditure in The Institution was a model of its kind and entirely in accordance with the best principles as followed by large concerns in Britain and elsewhere.

Mr. A. M. Strickland felt that members needed more time and explanation. The increased entrance fee might discourage younger men.

Mr. A. Cormack did not think that anybody who was asked to raise his efficiency should consider that he had been wasteful in the past. He doubted the value of an entrance fee.

Mr. Coombs said that in proposing the rejection of the two items he was not criticizing the staff. He believed they were most efficient. Nor was he criticizing the committees. The basic reason for the increases was expanding activities, and the proper and easy answer was to cut back the activities.

Lt.-Cmdr. R. F. Colvile opposed the increase in subscriptions of Associate Members and Associates at the age of 45.

Dr. Lindsay proposed and **Mr. Coombs** seconded an amendment to the main Resolution to add: 'subject to the omission of any alteration to Bye-laws 26 and 27' (items J and K).

In response to requests made during the discussion the President undertook that fuller explanations would be made on the points raised when the Council called another Special General Meeting after the 1958 accounts had been circulated.

Mr. R. S. Orchard said he would vote against the amendment because it implied that the membership would welcome a curtailment of activities. Institutions either flourished and expanded or they contracted and went on contracting. He was in favour of expansion.

On a show of hands the amendment was carried by 41 votes to 31.

After an explanation of item L (readmission to membership—Bye-law 39) there were no comments on the last two items M (voting at Council meetings—Bye-law 58) and N (examination and training—Bye-law 67).

The amended motion was carried, and the meeting ended.

25th June 1959 at The Institution of Civil Engineers (Corporate members only)

The President took the chair at 5.30 p.m. He said the purpose of the meeting was to consider two Resolutions. He moved (1) that each of the entrance fees payable pursuant to Bye-law 26 including the fees referred to in proviso (b) of that Bye-law be increased by one-half of the amount thereof and (2) that the increases shown in the Schedule to the Notice of the meeting be applied to the annual subscriptions payable by members pursuant to Bye-law 27. **Sir Willis Jackson** seconded both Resolutions.

The President explained that these were not amendments to the Bye-laws. They were Council Resolutions in accordance with the Bye-laws and were subject to confirmation by the meeting. He spoke of the narrow margin on which The Institution operated. Unless the subscriptions were increased as proposed to take effect in January 1960 they would be unable to take advantage of the offer from the bank to finance half the reconstruction on the favourable terms described at the meeting on the 9th April. They would have to raise the money by mortgage which would cost no less than £195000 extra. That was an economy they could make by putting subscriptions up. The demand for expansion of activities came not from the Council but from the members, particularly new members. Either The Institution would expand or it would begin to decline.

Mr. Wyke referred to the Council's Memorandum. He calculated that the excess expenditure over the years 1960–67 would total £936000. Allowing £176000 for the building there was £760000 to cover inflation and expansion of activities. He thought that inflation was settling down, but in any case that was a big figure. As to the sample reductions in activity shown in the Appendix he felt that the total saving, £30000, was neither here nor there. As the items listed (*Journal* and

meetings) were the things that kept the members' subscriptions flowing in and maintained the members' interest in The Institution he did not think they should be cut.

There was no need either for The Institution to stop expanding or for subscriptions to be increased. Economies and increased revenues could be achieved in other ways. The *Journal* and the *Proceedings* ought to be made to pay for themselves by bringing the advertising charges into line with the market. He asked that the proposed economies should not be put into operation, that the proposed increases be deferred until the accounts for 1960 were available, and that meantime the Council initiate an investigation of the financial affairs of The Institution with particular reference to increasing the advertising revenue of the *Journal* and *Proceedings*.

The President pointed out that the items in the Appendix were examples not proposals or recommendations. They had to build up the advertisement revenue carefully and comparatively slowly. He did not think it was fair to talk about losses, particularly for the *Journal* which was a free issue against a member's subscription.

Mr. Lucas said that in value terms the subscription income per member had decreased from £2·56 in 1938 to £1·48 in 1958. In money terms the increase was from £2·56 to £4·25—a very moderate amount.

Mr. Cormack by means of slides contended that purely nominal subscription increases of say £1 for Associate Members and Associates and 12s. 6d. for Graduates would close the gap. The main activities of The Institution were holding meetings and conferences and publishing the *Proceedings* and the *Journal* at a total cost of £40000. If they divided this useful expenditure by the gross expenditure they got an 'efficiency' figure of about 20% as against 28% two or three years before. It would be much more reasonable to have an entrance fee for new members only and a nominal transfer fee or refundable deposit.

Mr. S. L. M. Barlow considered the figures in the Council's memorandum realistic and the increases asked for modest. They had to have a little leeway. The proposals were completely well thought out and well founded.

Dr. R. J. Eldred thought economies exampled in the Appendix should be effected. The list of members should be issued every fourth year. Replacing the *Journal* by either a monthly 8-page or a two-monthly 16-page bulletin would save £18000 a year. The *Proceedings* should be published only in the form of separate papers which members could ask for, thus reducing printing costs. Until economies had been made the Resolutions should be rejected.

The President pointed out that The Institution held more than twice as many meetings in London and the Provinces as any two other engineering institutions put together. Any assumption that no attention had been paid by the Council to making economies was grossly untrue and extremely unfair to the devoted men who gave a great deal of their time free to the work of The Institution. Many of the points raised had been examined again and again by the committees. Very rigid economies had been made, and more were on the books.

Mr. J. R. Rylands was of the opinion that a 4% inflation would continue for ten years and showed that the increases asked for by the Council would not keep pace with the fall in the value of money. He was not sure that they were asking enough, but with a few economies they should get through.

Mr. Coombs said the prestige of The Institution rested on its meetings and the *Proceedings*. The Appendix showed that the meetings cost £4089 a year, which was negligible, and tended to show that the *Proceedings* paid for themselves. They should save the £18500 by changing the form of the *Journal*. Most members read the *Proceedings* most carefully; but many of his friends did not bother to open the *Journal* though he knew that was a mistake. Also they should save £3300 by stopping the education advisory service. The total saving, £22000, would meet the bank overdraft. Continuing the £22000 saving past redemption would restore the Building Fund.

Most disturbing of all was the increase in staff costs which might be an indication of Parkinson's law. Salaries had gone up 60% in five years. The cost of living had not increased to that extent in that time. In the last two years the rise in the cost of living had been only about 3%. The increase in staff salaries since 1956 had been above 33%. Had the staff increased that much or had they had that much increase in salary? The members had not been given enough information, and he urged the meeting to reject the Resolutions.

Mr. G. E. Miller felt the interests of the junior members should receive more consideration. Effectively 30% more subscription was being asked. If they went on putting it up the growth in membership would cease. He suggested making the increase gently in stages of 10%, or better still learning the value of thrift.

Mr. C. P. Aron was acting as proxy for a number of members who were in favour of changing the *Journal* to a bulletin. Quite frivolous matter in the *Journal* inflated the cost. Much of the content, for example a full account of the Annual Dinner, was of limited interest. They were in favour of reducing the cost of the *Proceedings*. They wanted more details of past and future economies.

Mr. A. T. Crawford referred to the goodwill required in the running of The Institution. They were debating the actual costs as recorded by the accountants which did not represent the cost which would be incurred if The Institution paid for every single item. Members of Centres and Oversea Branches spent much of their spare time looking after the interests of members in their local area. They had to be supported from headquarters. Some speakers had been a little parochial in their approach. The Council consisting of responsible engineers governed the affairs of The Institution. They had surveyed every aspect of the matter. It was impossible for individual members to have all the facets involved set before them. The men responsible were the Finance Committee.

When the President put the first Resolution Mr. Wyke, Mr. Dudley and Mr. F. E. Wellman demanded a poll.

Dr. Lindsay was alarmed that there was no choice but to vote either for or against on such an important proposal. But he imagined it did not mean that the Council could not come forward later with compromise proposals.

The President agreed but reminded the meeting of the necessity for quick action if the overdraft-redemption idea was to be possible in January 1960. He directed in accordance with Bye-law 86 that the poll be held at the Institution building on Thursday, 9th July 1959 between 4.30 and 6.30 p.m.

The three members with permission then withdrew their demand for a poll, and the first Resolution was carried on a show of hands by 102 votes to 81.

The three members then demanded a poll on the second Resolution which the President directed to be taken as indicated for the first Resolution. The meeting concluded.

As recorded on p. 414 of the July 1959 *Journal* the second Resolution was defeated at the poll by 739 votes to 423.

18th August 1959 at The Institution of Civil Engineers (Corporate members only)

Mr. S. E. Goodall, President, took the chair at 5.30 p.m. He proposed the confirmation of a Resolution of the Council that the increases shown in the Schedule (see September 1959 *Journal*, p. 525) be applied to the annual subscriptions payable by the members of The Institution pursuant to Bye-law 27.

He referred to the discussions at the previous meetings and said that the Council had decided to go forward with this Resolution, although it would afford a rather lower yield than the earlier proposals, because they felt it was essential to finance the building loan on the favourable basis of a bank overdraft rather than on the much more costly procedure of a mortgage. An increase of subscriptions on the 1st January 1960 was a necessary preliminary to the granting of the facility by the bank.

The present accounts were not in a healthy state. There had just been a considerable increase in printing charges. There was no provision for a reserve. The membership had agreed at a Special General Meeting on the 27th June 1957 that considerably improved accommodation at Savoy Place was needed, and the project had to be financed. Half the money was in the fund, and the rest had to be raised.

The Council believed that The Institution's activities should not be seriously curtailed but should continue to expand. In addition to the suggestions and criticisms made at the meetings on the 9th April and 25th June 1959 there had been a great volume of correspondence from members making suggestions. He therefore proposed to recommend to the Council the setting up of an *ad hoc* committee to study all these ideas and report to Council the action thought desirable and also to examine means of improving the corporate life of The Institution and the necessary processes of communication.

Sir Willis Jackson seconded the proposal.

Dr. Lindsay deplored the fact that no economies had been proposed by the Council. He held the Secretary responsible for that. They should vote against confirmation of the Resolution until economies had been made.

The President asked members to address their criticisms to himself not to the Institution staff.

Mr. Lucas said that the Finance Committee had made a most careful study of every possible immediate economy. All the suggestions which had been made would be considered by the *ad hoc* committee.

Mr. Wyke had sought from members of the Institution staff information on the gross income and expenditure for 1958, 1959 and 1960. If subscription fees were raised how did the Council propose to spend the extra money after payment of loan servicing? By his calculations a total of £885000 extra would come in during 1960–67. The loan repayment and interest would require only £145000 of this in that period. The report sent out after the last meeting was inaccurate. Moreover the Council had exceeded their authority by signing the contract for the last phase of the rebuilding, costing £200000, on the 9th July, the day of the poll, when they did not know where the money was coming from. So much false information had been issued by the Council that he asked that the meeting be adjourned so that true information could be circulated.

The President pointed out that the authority for signing the contract vested in authority granted by members at the Special General Meeting called for that specific purpose on the 27th June 1957. (See December 1957 *Journal*, p. 637.) It was quite a separate matter. If the subscriptions were not to be increased the money would have to be raised much less economically by loan.

Mr. Cormack re-presented his slides of the meeting on the 25th June 1959. He suggested that no information had been given on how The Institution's figures had been estimated. He extrapolated 1960 income as £320000. The Institution quoted £300000. By 1967 the difference reached £41000.

The surplus of income over expenditure in 1958 was £13000. Three years before it was about £4000 and three years before that it was £1000. That was a very healthy trend. He instanced a number of points in the circulated Memorandum on the finances of The Institution which he found inconsistent.

At the first Special General Meeting they had heard that the rebuilding would cost £460000. That figure had never been published. What were the arrangements for repayment? It appeared that they were to repay a bank overdraft in about 15 years. Comparing that with repayment by mortgage over 30 years it was no wonder that the difference was £195000. That difference was reduced if they repaid in a shorter time.

What was the markedly higher ground rent in 1984?

The Memorandum stated that on present subscriptions The Institution would be £33000 in the red by 1960. If they stopped all meetings in London and the Provinces and discontinued the *Journal* and *Proceedings* they could save £40000 according to the figures. If they stopped all activities they would just be in the black in 1960. But in 1962 they would be in the red.

His own figures also disagreed with the statement in the short explanatory memorandum that there would be a considerable adverse balance in the 1960 accounts irrespective of the rebuilding because of increasing costs due to the steady fall (even though at a reduced rate) in the value of the pound. The memebrship had been given incorrect statements which invalidated all the proxy votes cast in favour of the motion.

Mr. Lucas quite understood the difficulties of Mr. Cormack and Mr. Wyke in assessing the figures. The Finance Committee had spent many hours studying all the available figures and making and checking estimates with a view to ensuring that the facts presented were correct.

He had always spoken in net figures because the accounts showed net income and expenditure and because it was the net figures which determined subscriptions. Membership had increased over the past 30–40 years at a compound-interest rate of 4% per annum. The committee had to assume that between 1959 and 1970 the membership would increase by 28000 and that the service cost per member would be about £4.

They had to assume a 3% per annum inflation as in the past which meant that the pound would be halved in value again in the next 20 years.

In 1938 subscription income was £2·56 per member and net expenditure £2·7. In 1958 the expenditure had risen to £4·25 or by 60% whereas inflation had increased costs by a factor of 2·9. The new rates would increase subscriptions on a 1938-value basis to £1·85. Allowing for inflation the cost per member of running The Institution had steadily decreased. They believed that in the next ten years this cost would go down still further.

There was no doubt that The Institution would be in the red in 1960 or 1961 irrespective of the cost of the reconstruction because at the present time income from subscriptions was below the net expenditure and the gap was steadily increasing.

The President explained that the building had been held on a lease expiring in 1984 at a favourable low rate. Having taken the rebuilding decision it was discovered that the landlords, the Duchy of Lancaster, were thinking in terms of an increase from £2000 to £20000 or £25000 per annum in 1984.

After long negotiations the landlords had offered reasonable alternative terms. Until 1984 the ground rent would be £4000 and afterwards £12500. He did not know where Mr. Cormack had obtained the figure of £460000 for the rebuilding. The actual cost of structural alterations and extensions (including fees) was £387500.

Mr. A. F. Thompson thought that the fear lurking in many people's minds was that this substantial increase in subscriptions might happen again before long. He had discussed the matter with a number of members. Those who needed the qualification of The Institution could not very well turn down its increased cost. Those who did not need the qualification would not pay the subscriptions if they continued to rise.

He welcomed the President's proposal for an *ad hoc* committee. The Institution certainly benefited the electrical industry. Why had not the industry made a contribution towards the rebuilding?

The late Mr. T. E. Goldup said he had never enjoyed a meeting so much. He regretted the attacks on the Secretary and the Council. If the work of The Institution was to go on the members had to face the fact that they must support it.

Lt.-Col. K. H. Tuson asked whether the procedure being adopted was the proper one. A Resolution in practically identical terms had been defeated. The will of The Institution had been expressed by a proxy vote and a poll which should be regarded as binding.

Mr. Coombs thought that inflation was a step function depending primarily on war. Probably by 1967 or beyond they would have an appreciation and not a depreciation of the pound and they should therefore not rush into increased subscriptions based on fictional figures.

The trouble was the grandiose building schemes approved at a small meeting of 300. Why had not the Council thought again about the rebuilding before they had signed the last contracts in July when they had an indication of how seriously the members felt about the increased subscriptions? The presentation of the case had been badly handled, and no suggestions had been made on cutting management and administration costs.

Mr. L. W. Phillips said he had often criticized the Council. The difficulty had arisen because of lack of interest on the part of members. Out of the difficulty could come new vitality. They must in every way support the Resolution.

Mr. R. A. Laws felt that the case was not very convincing either way. He was a chartered accountant as well as a member, and the figures did not provide adequate information.

Mr. Melling suggested that some critics had blinded the meeting with figures. It would be wrong and foolish of the Council to ignore the possibility of further inflation.

Economies *had* been made, not only in principle but also in managerial detail. The greatest economy was the reduction in the cost of financing the rebuilding which could be effected by support of the Resolution.

Sir Willis Jackson's opinion was that the discussions of the last few months though not particularly happy had not been unhealthy. It was evident that the Council had not fully succeeded in conveying to some part of the membership the purposes of the policies of The Institution. He wished to assure the membership that the proposed *ad hoc* committee would make a thorough study of all the points raised.

The President put the motion, and on a show of hands it was carried by 369 votes to 139.

A poll was then demanded by Mr. Coombs, Mr. A. Bennett and Mr. Miller. The meeting proceeded to the poll forthwith.

As recorded in the August 1959 *Journal*, p. 487, the result of the poll was:

For confirmation of the Resolution 4701 votes
Against confirmation of the Resolution 736 votes
The motion was declared carried, and the meeting terminated.

Special Advisory Committee of the Council

HAVING supported the proposal made by the President at the Special General Meeting on the 18th August 1959 the Council have now set up a Special Advisory Committee to consider comments and suggestions made by members both in correspondence and at all three Special General Meetings held in 1959. The terms of reference of the committee are:

(a) To report to the Council on all the comments and proposals received from members, at meetings and in correspondence, on the activities and organization of The Institution and, where appropriate, to recommend suitable action

(b) To make recommendations to the Council on the ways and means of improving the channels of communication between the Council and the members in order to secure a better appreciation of the Council's activities and responsibilities, with a view to improving the corporate life of the body.

In determining the constitution of the committee the Council bore in mind the need for close liaison with those committees of the Council mainly concerned with the Special Advisory Committee's field of survey, as well as the desirability of ensuring representation of members in the Provinces and of younger members. To achieve this it has been decided that the committee shall consist of 14 members (including the chairman), seven chosen from the present Council and seven non-members of Council, two of whom have had experience of Council service in the past.

The following have agreed to serve :

Members of present Council

Chairman: O. W. Humphreys, C.B.E., B.SC., VICE-PRESIDENT
G. S. C. Lucas, O.B.E., F.C.G.I., VICE-PRESIDENT
J. Collins, MEMBER
A. T. Crawford, B.SC., MEMBER
D. C. Flack, B.SC.(ENG.), PH.D., MEMBER
B. L. Metcalf, B.SC.(ENG.), MEMBER
J. R. Rylands, M.SC., J.P., MEMBER
With the President (*ex officio*)

Past members of Council

A. R. Cooper, M.ENG., MEMBER
E. M. Hickin, ASSOCIATE MEMBER

Members who have not served on the Council

E. J. R. Hardy, B.SC.(ENG.), ASSOCIATE MEMBER
W. B. Laing, MEMBER
E. L. E. Pawley, O.B.E., M.SC.(ENG.), MEMBER
D. Pitts, ASSOCIATE MEMBER
D. N. Truscott, O.B.E., PH.D., B.SC.(ENG.), SC.D., MEMBER

The committee have already met. Members having comments or suggestions which they feel might usefully be placed before the committee are invited to write to the Secretary of The Institution.

High-power u.h.f. television transmitters

A brief account based on an Electronics and Communications Section paper (3070) entitled 'High-power television transmitters for bands IV and V' by T. S. Robson and T. M. J. Jaskolski, Dipl.-Ing., Associate Members. The paper is published this month in Part B of the Proceedings. Mr. Jaskolski is and Mr. Robson was formerly with E.M.I. Electronics Ltd. Mr. Robson is now with the Independent Television Authority.*

In order to increase the available number of channels it is expected to extend the television service into frequency bands IV and V (470–585 and 610–960 Mc/s). To investigate the television potentialities in this range a 10 kW television transmitter was developed and installed at the B.B.C. Television transmitting station at Crystal Palace.

Test transmissions were made between November 1957 and March 1958 to British standards (405-line positive-modulated vision at 654·25 and amplitude-modulated sound at 650·75 Mc/s) and between May and August 1958 to C.C.I.R. (Western European) standards (625-line negative-modulated vision at 654·25 and frequency-modulated sound at 659·75 Mc/s). Within the required bandwidth a practically flat response was obtained.

The technique in the u.h.f. range differs considerably from that at lower frequencies. At the upper end of band V the wavelength is just above 12 in.; therefore instead of resonant circuits consisting of coils and capacitors, coaxial cavities have to be used, i.e. short sections of coaxial metal tube whose electrical length (including the valve) is an odd or even multiple of quarter-wavelength at the operating frequency.

Transit-time effects and r.f. losses limit the use of orthodox valves in the upper u.h.f. region especially at higher powers and consequently higher interelectrode voltages. With the application of velocity-modulated valves or klystrons the transit time is made use of instead of being a handicap.

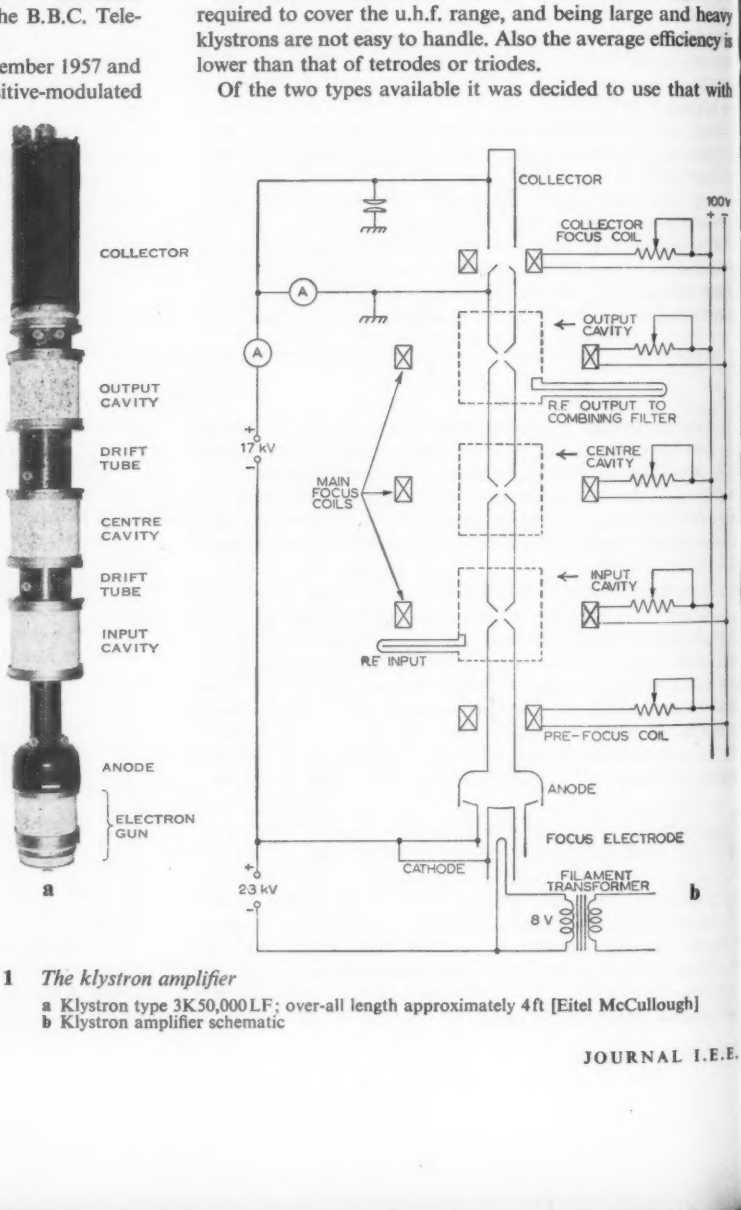
Klystrons

Two types of high-power klystron are available. The first has ceramic windows across the cavity gaps so that the cavities can be in part external to the vacuum, while in the second the cavities are wholly contained within the vacuum system of the valve and the operating frequency can be controlled by deflecting the walls of the cavities.

Compared with a triode or tetrode the main advantages of the klystron are that it is basically a simple and robust structure with widely spaced electrodes and cavities, which reduces the risk of feedback between them, and the power gain is considerably higher (for a three-cavity klystron tuned for maximum bandwidth it is approximately 100).

One disadvantage is that two or three different types are required to cover the u.h.f. range, and being large and heavy klystrons are not easy to handle. Also the average efficiency is lower than that of tetrodes or triodes.

Of the two types available it was decided to use that with



1 *The klystron amplifier*

a Klystron type 3K50,000LF; over-all length approximately 4 ft [Eitel McCullough]
b Klystron amplifier schematic

* This article and those following are based on, and written by the authors of current Institution papers. The authors have been asked to make these articles so far as possible interesting and of appeal to electrical engineers who have no specialized knowledge of the subjects, and the content of the articles is not necessarily confined to the subject-matter of the original papers

external cavities as the design of the cavities is more flexible and it is possible to load them as required.

Fig. 1 shows the klystron used and its schematic. It employs a cathode in which a tantalum block is bombarded by electrons from a heated tungsten filament maintained at −2·3kV with respect to the cathode. This bombarder and cathode, together with the anode (at earth potential), form the electron gun. The beam of electrons is first focused electrostatically, with further magnetic focusing by a number of coils energized from a 100volt d.c. source. The collector is near earth potential, and the cathode is maintained at −17kV. The water-cooled collector is capable of dissipating 50kW.

The klystron is mounted with the collector uppermost in a steel-sided frame containing also the resonant cavities and focusing coils (see Fig. 2). The end faces of the cavities are fitted with spring fingers and can be moved in or out by lead screws to tune to the required frequency. The cavity boxes are split and slide together to make contact through spring fingers with the klystron-cavity flanges. Rotatable loops are provided in the cavities for coupling to external loads or sources.

For 405-line operation adequate bandwidth can be obtained by stagger-tuning the centre cavity. For greater bandwidth damping loads can be coupled to the input or centre cavity or possibly to both. Stagger-tuning of the centre cavity and the introduction of a damping load reduce the gain of the klystron so that more driving power is required.

This klystron and its resonant cavities cover the range 580–720Mc/s. The output cavity is coupled to a 3in.-diameter coaxial feeder which can be connected by means of quarter-wave stub switches to a test load or via the combining filter to the aerial.

Modulated amplifier and low-power stages of the vision transmitter

To produce ample power to drive the klystron at frequencies up to 960Mc/s an experimental disc-seal tetrode type E2248 with a rated anode dissipation of 500 watts is used as a modulated amplifier in a cathode-modulated cathode-driven circuit. The input and output circuits consist of tunable coaxial cavities. The output cavity operates in a quarter-wave and the input in a half-wave mode.

The crystal oscillator unit of a conventional design using a crystal of about 9Mc/s and frequency doublers and triplers is followed by two frequency doublers each using a disc-seal u.h.f. tetrode type 4X150G capable of dissipating 150 watts. Their input circuits, fully screened, consist of strip-lines operating in the half-wave mode and driving the control grids, while the output circuits employ quarter-wave coaxial cavities.

The resonant cavities of the 4X150G and E2248 tetrodes cover the full range of bands IV and V, i.e. from 470 to 960Mc/s.

The vision modulator uses receiving-type valves only. The whole circuit consisting of amplifiers, clamp pulse generators and waveform predistortion circuits is contained in a single unit.

The output stage consists of six EL38 valves connected in parallel.

Sound transmitter

In the sound transmitter the low- and intermediate-power r.f. stages as well as the modulated amplifier are similar to the corresponding stages in the vision transmitter. A three-stage modulator is used for amplitude modulation. To improve linearity, over-all negative feedback of about 18dB is applied from the klystron output to the first stage of the modulator. Both in mechanical design and in electrical circuit the klystron amplifier in the sound transmitter is almost identical with the vision amplifier.

2 *The 10kW u.h.f. television transmitter*
Shown with sliding doors open. The klystron amplifier is in cabinet nearest camera

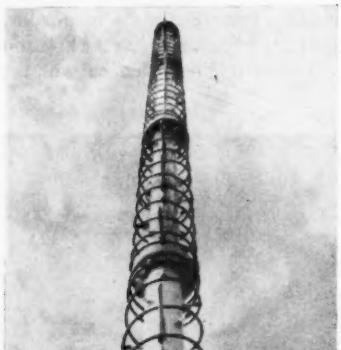
For 625-line tests the sound transmitter is frequency-modulated by means of a modulated drive unit providing about 5 watts at approximately 55Mc/s followed by a frequency-tripler stage feeding into the first 4X150G frequency doubler, the output of the second 4X150G doubler driving the klystron amplifier directly.

Power supplies

Selenium rectifiers have been used throughout the transmitters, being more reliable than valve rectifiers. The h.t. supply for the klystron beam delivers 2·0amp at 17kV. The

rectifiers for this unit are contained in an oil-filled tank approximately 4ft cube with cooling-water coils in the top of the tank.

The bombarder supply provides 0·7amp at 2·3kV. The negative terminal of this supply is at −19·3kV and therefore both the transformer and the metal rectifier are enclosed in a common oil-filled water-cooled tank. The filament of the klystron is operated at about −20kV and the filament transformer is cast in resin to provide the necessary insulation for the secondary winding.



3 *Helical aerial*
Axial length 32ft approximately

Aerial system

A helical aerial (Fig. 3) with a power gain of 20 is fitted on the top of the Crystal Palace 700ft steel tower. It is fed by means of an elliptical aluminium waveguide of 12 × 6in. axes (except for a short length of coaxial feeder inside the aerial itself). A combining filter guides the power from both sound and vision transmitters into the aerial and prevents any interaction between those two transmitters. After accounting for losses in the waveguide etc. the effective radiated power of the u.h.f. installation is about 150kW.

Conclusions

Using a commercially available klystron a successful vision transmitter with a peak output power of 10kW operating at about 650Mc/s, together with its accompanying sound transmitter, has been made. These transmitters fulfil all the usual requirements of the specifications for 405-line or 625-line vision transmitters and for high-quality sound broadcast transmitters (a.m. or f.m.).

The transmitters are straightforward to set up and easy to operate. In comparison with transmitters of equivalent power at lower frequencies the efficiency is lower, but it is not less than can be tolerated for the economic operation of television transmitters of such power.

For the successful exploitation of the u.h.f. channels for television broadcasting it may be necessary to construct transmitters of considerably greater power than those described in the paper. It is expected that this greater power can be produced by larger klystrons of the four- or five-cavity type with increased power gain and improved frequency response. There is no reason to doubt the suitability of wideband multicavity klystron amplifiers for future use in colour television.

Although this description of the transmitters relates to their use for television broadcasting it is clear that their application is not limited solely to this field, and the vision transmitter could readily be adapted for any service requiring wideband operation in the u.h.f. region, e.g. for multichannel communication utilizing tropospheric-scatter propagation. 621.397.61

Coastal deviation of radio waves

A brief account of an Electronics and Communications Section paper (3018) entitled 'Further studies of the deviation of low- and medium-frequency ground waves at a coast-line' by B. G. Pressey, M.Sc.(Eng.), Ph.D., Member, G. E. Ashwell, B.Sc., and R. Roberts, B.Sc. The paper is published this month in Part B of the Proceedings.

Because of the difference between the electrical constants of the sea and those of the land there is a deviation in the direction of travel of radio waves propagated along the surface of the ground and over a coast-line. The study of such a phenomenon is important to the use of radio waves for direction-finding particularly when the transmitter or direction-finder is shipborne.

Since the first report by Eckersley in 1920 of directional errors attributed to coastal deviation, or coastal refraction as it is commonly called, several theoretical explanations have been put forward. The early treatments were based on simple refraction processes at a boundary between two media, but in recent years more comprehensive studies of propagation over ground of mixed electrical constants have given detailed information about the deviations near the boundary.

The results of these studies are in general agreement and show that at low and medium frequencies the deviation is substantially independent of frequency, increases as the receiving point approaches the coast, and is proportional to the tangent of the angle at which the wave crosses the coast-line. The calculated deviations however are small, being less than 1° save in exceptional conditions.

The predicted increase in deviation as the direction-finder

approaches the coast was of particular interest since it might have accounted for the fact that Eckersley's observations gave a deviation of much greater magnitude than the simple refraction theory indicated. As has been demonstrated by earlier work* this increase of deviation is explained by the transient change in phase velocity which occurs as the wave crosses the boundary.

Sea-based transmission

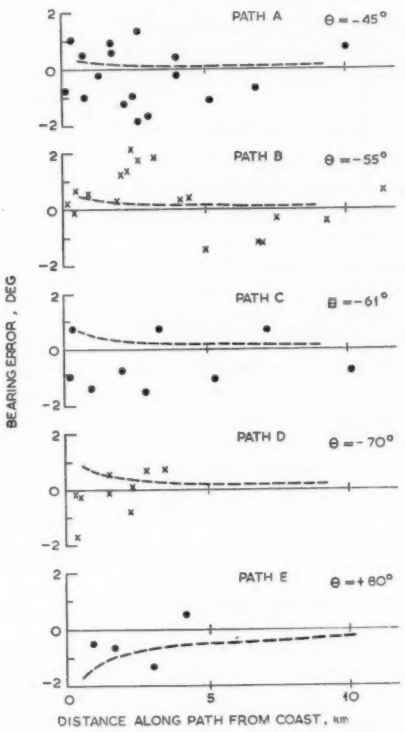
In order to check these theoretical conclusions a series of directional measurements were made at low and medium frequencies using portable direction-finders. The l.f. measurements which were made on a land-based transmitter with the direction-finder at sea have been described in a previous paper.* The measurements on medium frequencies described in the current paper were made in the converse conditions, i.e. with the transmission across the boundary from sea to land. They were carried out in the Sussex and Yorkshire coastal regions, and the numerous receiving sites used lay along paths radiating from the transmitters.

The results of one series of such measurements are shown in Fig. 1 from which it is evident that there is a wide scatter of the readings without any systematic trend with distance or with angle of incidence θ. Moreover the magnitude of these deviations and their changes from one site to the next are many times greater than the theoretical values given by the broken lines. The same general results were obtained at other sites and also from the l.f. observations made with the direction-finder at sea. The only systematic deviation was a sharp increase of up to 7° on the coast itself, i.e. within about one-tenth of a wavelength of the effective boundary.

Conclusions

It seems then that attempts to measure the deviation due solely to the change in ground constants have been thwarted by the presence of large bearing errors of a random nature which are attributed to ground irregularities and other causes not associated with the boundary. It is concluded therefore that on sites of good or average conductivity coastal deviation as such is unimportant provided that the direction-finder is not situated on the actual coast-line.

Although appreciable bearing errors may still be observed, particularly on land sites, they are not likely to be greater than those which would be obtained on signals not propagated across the coast. It is recognized that there may be coastal regions of very low ground conductivity where substantial deviations are theoretically possible, but even here the nature of the coast and hinterland may in practice be such as to give rise to errors of the same order as or greater than those due to the conductivity change at the boundary. 621.396.81



1 *Directional errors on east coast*

× ● Measured errors
– – – – – Theoretical errors

A brief account based on a Graduate and Student Section paper with the above title by A. P. Foster, B.Sc., Graduate. The paper was read before the Mersey and North Wales Graduate and Student Section at Liverpool on the 24th March and at Connah's Quay on the 2nd October 1958 and at a joint meeting of the Utilization Section and the London Graduate and Student Section at Savoy Place on the 12th March 1959. It was awarded a Premium by the Council. The author was formerly with the National Coal Board and is now with the United Kingdom Atomic Energy Authority.

* PRESSEY, B. G., and ASHWELL, G. E.: 'The deviation of low-frequency ground waves at a coast-line', *Proceedings I.E.E.*, Paper 2083R, July 1956 (103 B, p. 535)

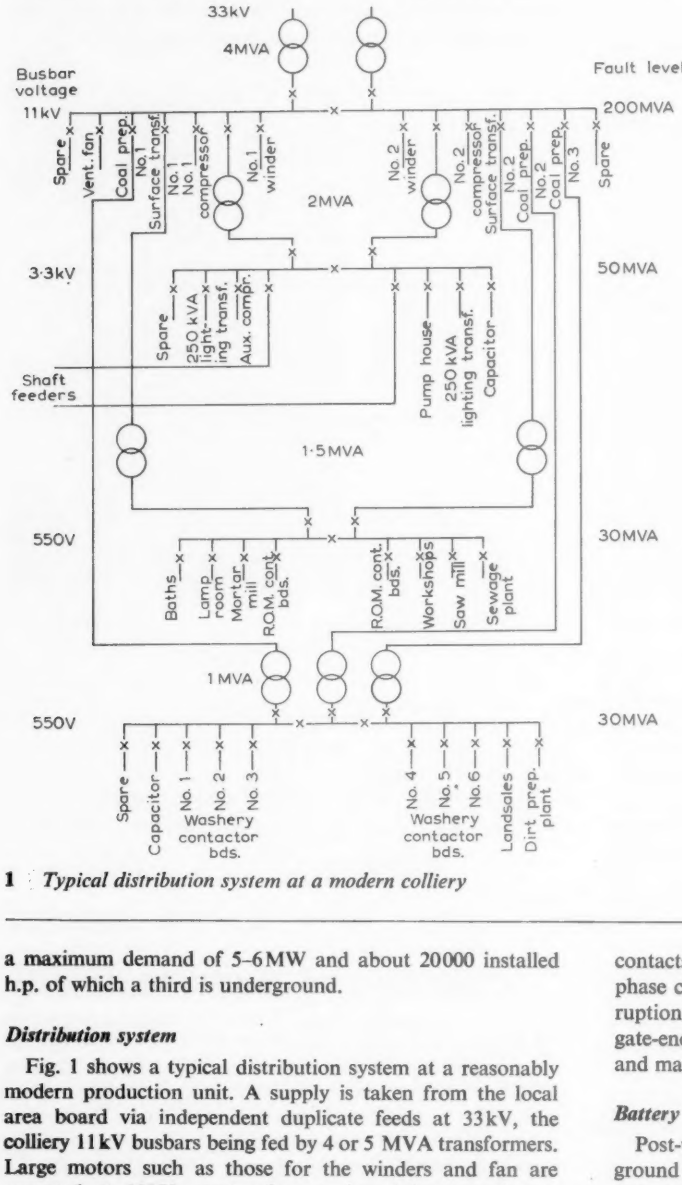
Coal-mining and electricity

To meet the demand for coal resulting from the Industrial Revolution manual labour was supplemented by power-driven machinery, and towards the end of the 19th century electrically powered machines were introduced. These early attempts at electrification did in a few cases result in methane explosions, and a great deal of opposition was aroused.

Nevertheless the use of electricity underground continued to increase because of its economies and advantages, and eventually research was undertaken to make underground electrical equipment safe. The outcomes were the principles of the flameproof enclosure for power equipment and the intrinsically safe circuit for signalling and telephone equipment.

Electrical machinery built to these standards proved safe and reliable in service, and underground electrification moved ahead rapidly.

Today electricity is the major form of energy in the mining industry both on the surface and underground. A large colliery producing one million tons of coal a year might have a maximum demand of 5–6 MW and about 20000 installed h.p. of which a third is underground.



1 *Typical distribution system at a modern colliery*

Distribution system

Fig. 1 shows a typical distribution system at a reasonably modern production unit. A supply is taken from the local area board via independent duplicate feeds at 33kV, the colliery 11kV busbars being fed by 4 or 5 MVA transformers. Large motors such as those for the winders and fan are operated at 11kV, most other services being supplied at the National Coal Board's standards of 3300 and 550 volts. Oil circuit-breakers are normally used in the parts of the distribution system operating at 3·3kV and above; in the 550volt system air-break circuit-breakers are installed. Probable fault levels on the various parts of the system are indicated, that on the shaft feeders usually being kept below 50MVA.

The pit-bottom substation is the underground distribution point for the 3·3kV network, but 3·3kV/550volt transformers may be installed to provide a supply for the type of local service shown in Fig. 2. Underground circuit-breakers are self-contained units which can be used singly or bolted together to make switchboards. Most underground transformers are rated at 150kVA and to facilitate transport along mine roadways are restricted in height and mounted on wheels.

District substations fed from the 3·3kV system supply the coal-producing districts at 550 volts, these substations being advanced periodically as the mine workings move forward.

Underground motor control

All coal-face motors and most other underground motors operate on the 550volt supply and are of the squirrel-cage induction type. Each is controlled by a contactor fitted with the following protective devices:

1. No-volt protection—an inherent feature of the contactor
2. Overload protection
3. Earth-leakage protection with automatic contactor lock-out when a cable fault exists
4. Earth-continuity protection between the box and the motor
5. Provision for remote control of the contactor
6. Supply-isolating facilities.

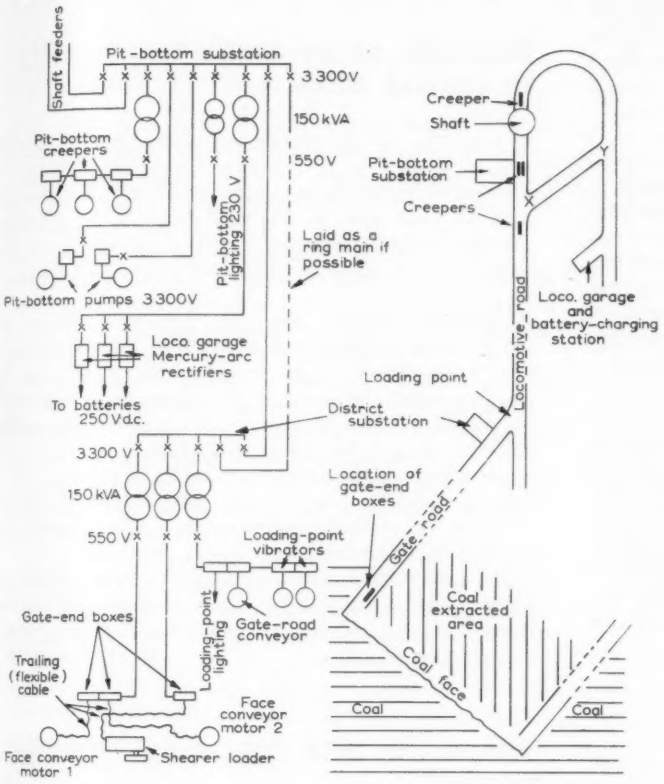
The contactor units or 'gate-end boxes' are connected to the motors by five-core flexible trailing cables, one core being used as a contactor control. Thus if either of the flameproof plugs and sockets by which the cable is connected to the gate-end box and the motor is disconnected the control circuit is broken and the exposed phase terminals cannot be energized.

Drum-type phase reversers are fitted to some motors to provide reversing facilities, the control circuit from the gate-end box passing through contacts on the drum. These control contacts open before the phase contacts and close after them, so that current interruption does not occur on the phase reverser but on the gate-end box contactor, which is more accessible for repair and maintenance.

Battery locomotives

Post-war modernization of mines has introduced underground locomotive haulage for mine cars on a larger scale then ever before, the locomotive being either storage-battery or Diesel powered. The modern battery locomotive is a two-axle unit rated at 90h.p. weighing 13 tons and carrying a 250volt 400Ah battery. As in normal locomotive practice the motors are series-wound, of an integral construction with their gearboxes and hung on their own wheel axles. Motor

control is by means of a cam controller in the driver's cab which operates on the auxiliary circuits of the motor line contactors.



2 *Underground system of colliery*

Winding engines

The modern winder can range from 50 to 4000 h.p. or more, both a.c. and d.c. drives being used. Recently introduced closed-loop control systems provide speed and load compensation, motor-torque control, and acceleration and retardation control. The control-system amplifiers are usually rotating machines, but transductors used in conjunction with mercury-arc rectifiers have been used.

Closed-loop systems enable the theoretical winding cycle to be closely adhered to and maintained in spite of load changes and greatly reduce the strain on the winding engineman.

Surface installations

Apart from the winding engines a large amount of normal industrial electrical equipment is used in surface installations.

Supplies must be provided and equipment maintained for repair workshops, boilerhouses, pithead baths, offices, ventilation fans, and coal-preparation plants. The latter may contain well over 2000 h.p. in electrical drives, all of which must be sequence-controlled to ensure that plant start-up is carried out in the correct order and to prevent a pile-up of coal by closing down the necessary sections of plant if a breakdown should occur.

622.33:621.311.6

Logarithmic motor

Synopses of papers

THE following are synopses of papers published in the *Proceedings* which have not been read at Institution meetings and which have not been reviewed in the *Journal*. They are included here primarily for reference. The papers have not been published individually, as have those for reading at meetings, but reprints will be available in due course

A synopsis of a Utilization Section paper (3149) entitled 'The Logmotor—a cylindrical brushless variable-speed induction motor' by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., Member, E. R. Laithwaite, M.Sc., Ph.D., Associate Member, J. F. Eastham, M.Sc., and L. S. Piggott, M.Sc., Associate Member. The paper will be published in Part A of the Proceedings. The authors are in the Department of Electrical Engineering, University of Manchester.

IN a conventional induction motor the synchronous speed at the rotor surface is set by the phase difference between currents in adjacent slots and the spacing of the slots. The synchronous speed may be increased by changing the phase of the current in each slot progressively so as effectively to stretch the poles. The authors describe a transformer arrangement giving a multiphase output which can provide such a 'phase-stretching' system to be used to supply the stator of a squirrel-cage induction motor.

The transformer is similar to a conventional phase-shifting transformer except that the pitch of each coil of the primary is proportional to the logarithm of its distance from a fixed point in the system. The primary and secondary of the transformer are analogous to the C and D scales of a slide rule, and movement of the primary relative to the secondary results in a variation of the phase increment between adjacent secondary coils.

The secondary is connected to the stator winding of the motor in such a way as to provide a uniform-velocity field in the latter, the velocity being varied by adjusting the position of the primary of the transformer.

The construction of an experimental machine is described and test results over a speed range of 4 : 1 are included.

621.313.333.2:621.316.718.5

A.M. noise spectrum in reflex klystrons

A synopsis of an Electronics and Communications Section paper (3032) entitled 'The spectral density of the a.m. noise in reflex klystrons' by H. Häggblom, Tekn.lic. The paper is published this month in Part B of the Proceedings. The author is with Aktiebolaget Svenska Elektronrör, Sweden.

THE a.m. noise spectrum in reflex klystrons is treated experimentally and theoretically. The frequency range of the measurements is 1–100 kc/s from the signal frequencies which are 4·7 and 9·3 Gc/s. It is shown that the measurement equipment cannot consist of a crystal detector immediately followed by a low-frequency amplifier because the crystal noise up to about 20 kc/s is greater than the klystron noise. To reduce the effect of crystal noise the klystron is frequency-modulated and the measurement equipment consists of a crystal diode as first detector, an i.f. amplifier, a vacuum diode as second detector and a selective l.f. amplifier.

The measurements show that the noise density is, with great accuracy, constant in the actual range. This agrees with the theory which is based on a treatment by Knipp. The deviation from Knipp's noise formula is due to the introduction of an inherent synchronizing effect in the noise current. The theory indicates that the noise is approximately constant up to a displacement of 10^{-4} to 10^{-3} from the signal frequency.

621.385.623.5 : 621.317.34

Spherical induction motors

A synopsis of a Utilization Section paper (3036) entitled 'Development and design of spherical induction motors' by Prof. F. C. Williams, O.B.E., D.Sc., D.Phil., F.R.S., Member, E. R. Laithwaite, M.Sc., Ph.D., Associate Member, and J. F. Eastham, M.Sc. The paper will be published in Part A of the Proceedings. The authors are in the Department of Electrical Engineering, University of Manchester.

THE first major development described is concerned with the arrangement of stator blocks. A previous paper described a system in which four were arranged around the rotor. The new lay-out involves the use of only two blocks containing pre-skewed slots. The arrangement of the laminations and slotting is such that the two blocks can be rotated as a unit to produce speed adjustment. This produces a more uniform effective field velocity over the active surface of the stator. It equalizes the magnetic pull between rotor and stator and has several other design advantages which are fully discussed.

The earlier theory of the spherical motor is extended to the case of machines with pre-skewed slots. Test results obtained from several experimental machines are given. In the light of these results a procedure for designing spherical motors is developed. Several aspects of manufacturing procedure such as the required numbers of rotor bars and rings have been investigated, and the practical results of these tests are included.

A short section of the paper is devoted to the performance of spherical machines when used as induction generators.

621.313.333

Balanced aerial connected directly to coaxial cable

A synopsis of an Electronics and Communications Section paper (3079) entitled 'The performance of a balanced aerial when connected directly to a coaxial cable' by G. D. Monteath, B.Sc., A.Inst.P., and P. Knight, B.A., Associate Members. The paper will be published in Part B of the Proceedings. The authors are with the British Broadcasting Corporation.

MEASUREMENTS have been made of the radiation patterns of typical aerials, such as would be used for domestic reception in the v.h.f. band, connected directly to a coaxial cable without the intervention of a balance/unbalance transformer. The vertical radiation pattern may be appreciably distorted owing to the excitation of currents on the outside of the cable, and the sensitivity to vertically polarized interference originating near to and below the aerial may be increased. The distortion of the radiation pattern appears to be less serious with directional aerials.

The use of a balance/unbalance transformer or a balanced feeder would be desirable, but unless the input circuit of the receiver is either balanced or screened and unbalanced no ideal solution exists.

621.396.67 : 621.396.8.029.6

Alternator with field-form envelope control

A synopsis of a Supply Section paper (3089) with the above title by J. W. Pannell, M.Sc.(Eng.), Associate Member. The paper will be published in Part A of the Proceedings. The author in is the Department of Electrical Engineering, Derby and District College of Technology.

THE author considers a method of waveform synthesis by changing the generated waveform envelope as an alternative to the more usual procedure in which the desired non-sinusoidal waveform is obtained by mixing selected constituent harmonics. A rotating machine is used, and continuous variation of the shape of the generated waveform may be made with the machine in motion.

A preliminary version of this apparatus has been constructed from a modified induction motor, but owing to the inherent heteropolar form of the magnetic circuit this machine will only synthesize waveshapes containing the odd-harmonic series.

For convenience in observation and measurement a fundamental frequency of 50 c/s has been selected for the prototype, but with suitable modification of the magnetic circuits higher frequencies and also waveforms containing both odd- and even-harmonic series could be obtained.

621.313.3

CORRESPONDENCE

ELECTRIC CONTROL OF STAGE AND TELEVISION LIGHTING

WITH reference to Mr. Sharp's letter in the September 1959 *Journal*, p. 534, I showed no enthusiasm for punched cards because I believed that no such system was applicable to television production and that the financial reach of the theatre did not extend that far.

To obtain confirmation or otherwise of these beliefs a complete control desk and relay bank working with standard punched cards was constructed and demonstrated on the 29th April 1959 to 110 television-lighting engineers* representing the B.B.C. and all programme contractors here.

Not one voice was raised in favour of the punched cards although 'shift'† which had also been built into the desk came in for a lot of praise. The editing, sorting and modification of cards are too slow and cumbersome for the hectic and confused pace of rehearsal and run-through. An instantly accessible magnetic-drum system has now to be explored though price will be a problem.

In the United States the first public sign of punched-card activity in lighting came with a publicity 'hand-out' to the Press on the 5th May 1959, six days after the above demonstration. This must have provoked the remarks in *Business Week* referred to by Mr. Sharp. So far there has been no installation in a television studio. I understand from the president of the American company concerned that the market where he really expects to sell his system is schools!

In the United States stage lighting often forms part of the curriculum in schools, and the punched cards will give the pupils' tests a permanent form which can be marked. I have always believed that stage lighting should form an essential part of the training of an illuminating engineer, but so far not even this idea is accepted in educational circles here, alas!

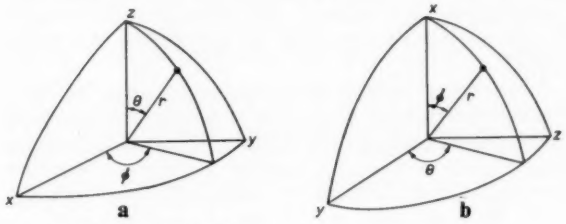
F. P. BENTHAM
29 King Street
London W.C.2

1st October 1959

SYMBOLS FOR SPACE CO-ORDINATES

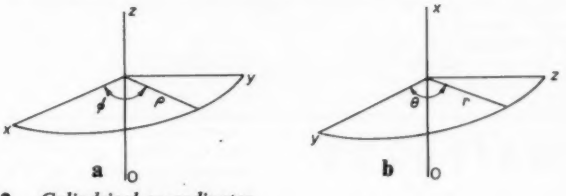
I CANNOT help feeling that in pleading for a rational system of co-ordinates for dealing with electromagnetic-wave problems (September 1959 *Journal*, p. 533) Prof. Barlow is tilting at a windmill largely of his own making. Although his proposal is quite logical it represents a considerable departure from what I regard as established practice and does not seem to me to offer any real compensating advantage.

Let us start with what I understand to be the 'standard' system of spherical co-ordinates, that shown in Fig. 1a. Out of the first 13 mathematical and engineering textbooks I chose at random from a technical library, 11 used the system of Fig. 1a and the others used a similar system but with ϕ replaced by ψ in one case and by λ in the other. Prof. Barlow however wishes to use the system shown in Fig. 1b in which θ and ϕ are interchanged. The only implied argument for this interchange is that in proceeding to the cylindrical system



1 *Spherical co-ordinates*
a Standard
b Barlow

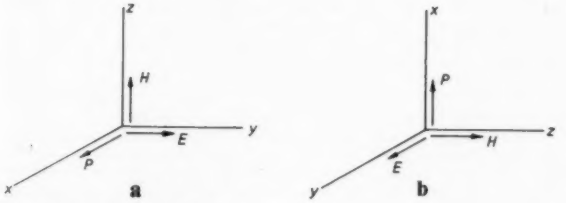
(Fig. 2) we retain θ instead of ϕ. This is claimed to be preferable since ϕ is generally used for a phase angle; but Prof. Barlow has no such scruples about using ϕ in the spherical system! If we do want a standard symbol for an arbitrary phase angle ought we not to think of a new one rather than purloin one from the co-ordinate system?



2 *Cylindrical co-ordinates*
a Standard
b Barlow

To the best of my knowledge the system in Fig. 2a is widely used in electromagnetic-wave problems involving cylindrical co-ordinates. Prof. Barlow's proposal to use the same symbol for distance from the origin (Fig. 1b) and distance from the axis (Fig. 2b) will surely result in confusion when transforming from one system into another should this be necessary during the course of a problem.

Coming now to the Cartesian system Fig. 3 shows the



3 *Cartesian co-ordinates*
a Standard
b Barlow

* *Control*, May 1959, 2, (11), p. 109
† *Proceedings I.E.E.*, 1958, 105A, p. 502

Correspondence (continued)

logical development of the 'standard' and Barlow systems; propagation along the $0x$ axis is illustrated in both cases. What is wrong with the system of Fig. 3a? Fig. 3b is precisely the same but with the axes rotated through a right-angle.

I suspect Prof. Barlow's objection would be that in some problems, for instance that of a cylindrical waveguide, it is convenient to use cylindrical co-ordinates. In the 'standard' system the variable would then be z which I would accept. However if Prof. Barlow insists on making x the variable I see no objection to replacing z by x in these special cases. Surely this is not too much to ask a student to take in his stride.

I hope I do not appear recalcitrant in suggesting that Prof. Barlow has not made out a very convincing case for throwing overboard the established co-ordinate systems. A cleavage on this question between the engineer and the mathematical physicist who has contributed so much to this field of activity seems to me too high a price to pay.

H. PAGE, M.SC., MEMBER

B.B.C. Research Department
Kingswood Warren
Tadworth, Surrey

6th October 1959

LOAD FACTOR

I WAS most interested in the letter by Mr. O. D. Robinson (August 1959 *Journal*, p. 470) and rather surprised to see no immediate comment on it. I have been connected with an attempt to stimulate further thought on this subject via the South Eastern Electricity Consultative Council in recent months.

I should like to suggest that charges to a consumer can be based on one of two approaches: first that he should pay what the market will stand; secondly that he should pay what it costs to provide him with the service he expects together with a profits or contingency percentage. It is this last basis that I would hope to be adopted by any monopoly. Presumably this is the argument behind any tariff which is a function of load factor.

Nevertheless the alternative philosophy of making the customer pay what the market will stand is unanimously adopted by the electricity supply authorities when they are dealing with the domestic consumer. The two-part tariff in general use cannot be satisfactorily interpreted in terms of allocated capital charges and running cost, and there is little correlation between either floor area or the number of rooms and quantity of electricity used. The difficulty appears to be the absence of an agreed improved alternative. Little or no research appears to be proceeding on these lines where surely it would not be too difficult to come to a firm conclusion. I should like to suggest that The Institution with its required active interest in research should see that this matter is pursued.

D. B. MANWARING, B.SC., ASSOCIATE MEMBER

5 Garlinge Road
Southborough
Tunbridge Wells, Kent

20th October 1959

OBITUARY

DOUGLAS HOWARD BISHOP

Douglas Howard Bishop, B.SC., who died on the 23rd June 1959 was a native of Lichfield, Staffordshire, and was born on the 8th September 1879. He was educated at Queen Mary's High School, Walsall, and won a scholarship which enabled him to proceed to Mason University College, Birmingham, where he graduated B.Sc. Subsequently he received practical training with Belliss and Morcom, Birmingham.

In 1901 he joined the Dundee Corporation electricity department as a switchboard attendant. Rapid promotion followed and by 1907 he was closely associated with his chief, Major Harry Richardson, in the preparation of schemes for the expansion of the undertaking which took final form in the Carolina Port generating station which started operating in 1909. He was in charge of the station until 1922 when he was appointed engineer and manager of the electricity department. He retired in 1941 owing to ill health.

He was recognized as a most competent electrical engineer and under his careful and painstaking leadership the Dundee undertaking expanded and flourished. He will be remembered by many engineers up and down the country for his encouragement and helpful advice while they were in training at Dundee.

His work was his only hobby, and except for an occasional game of tennis in his younger days he took part in no kind of sport, his only recreation being long country walks usually alone. He was a bachelor but had his sister as a companion for a few years until she predeceased him several years ago.

He joined The Institution as a Student in 1902 and was elected an Associate Member in 1907 and a Member in 1920. He was vice-chairman of Dundee Sub-Centre in 1924–25 and served on the Committee in 1925–26 and from 1928 to 1945. He was chairman of the Scottish Centre in 1932–33 and served on the Committee from 1934 to 1937.

P. P.

LAURENCE HUDSON ASHDOWN CARR

Laurence Hudson Ashdown Carr, M.SC.TECH., was born in Manchester on the 10th March 1887 and died on the 27th August 1959. He was educated at Rossall School and at the Manchester School of Technology where he obtained his degree. He was apprenticed to the Lancashire Dynamo and Motor Co. and entered the design office specializing in induction motors. He became assistant chief designer with the company in 1912. In 1915 he joined J. H. Holmes and Co., Newcastle, and was appointed chief designer in 1918.

He joined Metropolitan-Vickers Electrical Co. in 1920 as chief designer of large induction motors in which field he became widely known for his work in connection with the development of the synchronous induction motor. He designed the a.c. traction motors for the Hungarian State Railway locomotives: these multispeed induction motors were unique in their construction and method of control. He transferred in 1934 to consulting engineer on patents until his retirement in 1955.

He was a member of the Court of Governors of Manchester University from 1949 to 1955 and had been president of both the Manchester Astronomical Society and the Manchester Amateur Photographic Society. He was second-in-command of a Trafford Park company of the Home Guard during the Second World War and was a member of the Hale Barns Tennis Club for many years. He was very interested in sundials and had an extensive collection of photographs of antique types; astronomy and the technical aspects of history, especially Egyptology and the Roman occupation of Britain, also attracted him.

He wrote a memorandum on the M.K.S. system which was published by the British Standards Institution, and he played a major

part in drafting a British Standard on photographic-film speeds and exposure times.

He had a lively interest in the Institution Examination, an activity which he continued after his retirement. About two years ago he organized with J. C. Wood a series of postgraduate lectures at the Manchester College of Science and Technology on patents for engineers.

His wife predeceased him in 1957.

He joined The Institution as a Student in 1905 and was elected an Associate Member in 1912 and a Member in 1918. He was a most enthusiastic and stimulating supporter of Institution activities and will be greatly missed by his many friends and admirers. He took a very active part in the organization of the North Lancashire Sub-Centre and until he left Manchester regularly attended their meetings.

He was honorary secretary of the North-Western Centre from 1935 to 1942, chairman in 1942–43, honorary treasurer from 1945 to 1955, served on the Committee in 1925–26 and in 1934–35, and was chairman of the Installations Group from 1944 to 1946. He served on the Examinations Committee from 1945 to 1953 and in 1958–59, on the Joint Section A Examinations Committee from 1952 to 1954, and on the Engineering Institutions' Examinations Part 1 Committee in 1954–55 and from 1956 to 1959. He was a member of Council from 1945 to 1948 and honorary secretary of the Manchester Student Section in 1909–10.

He was awarded a Student premium in 1908 and 1909, the Ayrton premium in 1922 for his paper entitled 'Induction-type synchronous motors', and a premium in 1950 for his paper entitled 'The M.K.S. or Giorgi system of units'. He had six other papers published in the *Journal*. H. D.

ALFRED THOMAS DOVER

Alfred Thomas Dover who died after a short illness on the 6th September 1959 was born on the 21st June 1884. He was educated at Brighton Municipal Secondary School and received his technical education at Brighton Technical College, subsequently joining the British Thomson-Houston Co., Rugby. It was while he was at Rugby that he became interested in electric traction and this subject remained his major interest throughout his life.

He was appointed lecturer in electrical engineering at Battersea Polytechnic in 1909 and became head of the department in 1919 which position he held until his retirement in 1949.

He was interested in music and in cricket, but his real hobby was writing technical books. He was internationally known for his 'Electric traction' and his 'Theory and practice of alternating currents' and was actively engaged on the revision of the former work at the time of his last illness. His reputation was enhanced by the examination work in electrical subjects he undertook for London University and other examining bodies.

Dover was a man having a quiet and retiring nature but very warm-hearted and generous to his friends and will always be remembered with affection by his old students. He is survived by a daughter.

He joined The Institution as an Associate Member in 1909 and was elected a Member in 1919. He was awarded a premium for his paper entitled 'A universal "chart" method of calculating starting rheostats for direct-current motors' which was published in the *Journal* in 1922. He served as a member of the Meter and Instrument Section Committee from 1939 to 1942. H. C. M.

FREDERICK THOMAS JACKSON

Frederick Thomas Jackson, O.B.E., who was born on the 18th March 1881 died on the 14th August 1959. He was educated at Bewdley Grammar School and after four years' farming on his father's farm became clerk and then secretary of the New System Private Telephone Co.

He founded Telephone Rentals Ltd. in 1909 and the Telephone Manufacturing Co. in 1914, fostering their growth and remaining chairman of the former and chairman and managing director of the latter until his death. He was vice-president of the National Union of Manufacturers in 1949 and honorary treasurer from 1942 to 1948. He was three times chairman of the Telecommunications Engineering and Manufacturing Association and a member of the Grand Council of the Federation of British Industries.

The development of British industry owes much to those descended from yeoman-farmer stock, men who expect obstacles and use a native shrewdness in overcoming them; 'F. T.' was typical of the breed. An abiding impression is of kindness, but kindness founded in strength. He was a silent man, oracular in his rare utterances and impressive when obviously unimpressed by ebullience or philosophic doubts. He was an optimist not in the sense of 'it will be all right' but rather in the certainty that it would be. Those who worked with and for him can say in valediction *quo fas et gloria ducunt*.

He was elected a Companion of The Institution in 1944. P. P. E.

ROY STUART JONES

Roy Stuart Jones who was born on the 18th May 1887 in Aberdeen died on the 6th July 1959 while on holiday. He served an apprenticeship with Alexander Spark and Sons and studied at Gordon's College, Aberdeen. After obtaining a diploma in electrical engineering at the Royal Technical College, Glasgow, he joined the test department of the British Thomson-Houston Co. in 1913. In 1916 he moved to a.c. machine design and in 1919 to the handling of contracts for rolling-mill main drives. In 1936 he was appointed manager of the plant sales department, retiring from this position in 1954.

Tall and with a natural dignity, his word was his bond and even his most bitter business rival never failed to recognize and respect his absolute integrity. He was an excellent host and was always happiest, on occasions even boisterously so, when surrounded by his friends.

He joined The Institution as an Associate Member in 1943 and was elected a Member in 1947. R. M. G.

CHARLES MELMOTH BAILEY MERSH

Charles Melmoth Bailey Mersh, M.B.E., who died at his home in Merton Park on the 29th January 1959 was born on the 25th October 1884. He was educated in India and was a pupil of Crompton and Co. for four years. After holding appointments on the staff of the company he was sent as the company's representative to Nagpur, India, in 1909. It was during this period that steps were first being taken mostly by private undertakings for the provision of electricity supplies in many of the cities and towns of India.

It was as a result of his efforts in this work and his wide technical knowledge and experience of the problems involved, particularly of the special conditions prevailing in India at the time, that he was invited to become electrical adviser to the Government of the Central Provinces and Berar and later to the Bhopal State Government as well. He continued to hold these appointments till 1939 when he retired from government service.

For the next ten years he worked privately as a consulting engineer with his headquarters in Bombay. His practice grew rapidly and his services were in continuous demand in connection with many of the electrification schemes that were being developed or extended in the Bombay Presidency and Western India. Towards the end of 1948 he retired and returned home.

He was of a kindly and generous disposition. He was very highly respected and a well known figure in Nagpur and the Central Provinces. He is survived by his widow and a married daughter.

He joined The Institution as a Student in 1904 and was elected an Associate Member in 1909 and a Member in 1921. He was an Associate Member of The Institution of Mechanical Engineers. He was appointed a Member of the Order of the British Empire in 1940. R. M. T.

HENRY WAUD TATTERSALL

Henry Waud Tattersall who was born on the 14th February 1907 died suddenly at Johannesburg, South Africa, on the 24th June 1959. He was educated in Preston, Lancashire, and served his apprenticeship with the English Electric Co. from 1922, studying part-time at the Harris Institute. After completing his apprenticeship he served several years in the electric-traction organization at Preston first in the test department and then in traction-control design and outside erection departments before he was appointed in charge of traction-machine test at the Bradford works of the company in 1931. In 1936 he entered the traction-machine design department where he served until he joined the Forces in 1941 and attained the rank of captain in the R.E.M.E.

After being demobilized in 1946 he joined the South African branch of the English Electric Co. at Benoni near Johannesburg where he was able to apply his wide experience in manufacture and design of electric machines in the building up of their new factory there. He was finally appointed assistant manager and chief engineer at the Benoni works.

In 1958 he joined the Associated Electrical Industries group in South Africa at the First Electric Corporation in Johannesburg.

He joined The Institution as an Associate Member in 1939 and was elected a Member in 1947. D. A. L.

PAPERS AND MONOGRAPHS
published individually this month

Papers accepted for reading at meetings and monographs are first published individually and are republished later in the Proceedings of The Institution; as soon as the separates are available they are described in this feature. The papers are supplied free of charge; the price of a monograph is 2s.

In addition reprints of papers read at meetings including the discussions thereon and of papers not read at meetings become available, price 2s., within two months of their appearance in the Proceedings.

Applications quoting the serial number of the paper, monograph or reprint as well as the author's name and accompanied by a remittance where appropriate should be addressed to the Secretary of The Institution. For convenience books of five vouchers for this purpose can be obtained in advance, price 10s.

Those who obtain a copy of a paper published individually are urged—if they do not take the Part of the Proceedings in which it will be republished—to apply in due course for a reprint as this is the final and correct version and includes the discussion.

PAPERS

Application of low-pressure resins to some high-voltage switchgear designs *Paper* 2835S: *Part A*

T. R. MANLEY, B.SC., K. ROTHWELL *and* W. GRAY

THE authors outline the properties of the epoxy and polyester resins which were chosen for application to high-voltage switchgear. Manufacturing methods for casting and impregnating with these resins and for reinforcing them are outlined, and the problems which have arisen and the steps taken to overcome them are described.

Examples are presented of the ways in which the resins may be applied to various high-voltage switchgear designs, and an indication is given of the advantages so obtained.

To be read on the 26th November 1959

Field suppression of turbo-alternators *Paper* 3161S: *Part A*

J. R. HILL, B.SC.(ENG.), A. HUNT, B.SC.(ENG.), W. J. JOYCE, B.SC., *and* D. H. TOMPSETT, B.SC.(ENG.)

THE paper is concerned with the field suppression of synchronous machines by means of a discharge resistor connected across the field winding and with the suitability of such a method for alternators of 100 MW and above. Expressions are given for the field current when a 3-phase fault is applied to the armature terminals and also for the currents and voltages during field suppression. The effect of the discharge-resistance value on the field overvoltages, the field circuit-breaker arc duration and the stator fault damage is discussed.

Many field-suppression tests have been made on turbo-alternators in conjunction with short-circuit tests on the alternators. Results of some of these are presented and are compared with values of theoretical expressions derived.

The duty on the main and discharge contacts of the field circuit-breaker and methods of proving their suitability for the duty are considered. The use of a synthetic circuit for proving the interrupting capacity of the main contacts is unsuitable if the arcing time is long.

Other forms of field suppression are available. These may give improved field suppression but either require more complex circuits or are unlikely to be suitable for very large alternators.

It is concluded that the value of the discharge resistance should be determined by the permissible field overvoltage and circuit-breaker arc duration.

To be read on the 9th December 1959

Frequency patterns for multiple-radio-channel routes *Paper* 3033E: *Part B*

B. B. JACOBSEN, B.SC.(ENG.)

IN radio trunk systems a number of two-way radio channels are used over a common route with repeaters provided at intervals. Each radio channel carries a baseband signal by frequency modulation of the radio carrier frequency. The baseband signal may consist of an assembly of single-sideband telephony channels and/or a television channel.

When choosing the frequency pattern for the radio channels selectivity requirements are found to arise, not only from the primary fact that the channels are adjacent in the frequency spectrum but also from secondary features of the equipment such as for instance the intermediate frequency used in the heterodyne repeaters.

The author considers the effects which give rise to such selectivity requirements and shows how to choose the channel frequency pattern and the intermediate frequency to minimize the selectivity requirements. The choice takes account of amplitude non-linearity in waveguide circuits. The presence of this was expected on theoretical grounds and has been confirmed by measurement.

A specific frequency pattern is worked out for a route with six two-way channels in which each radio channel can carry at least 600 telephone channels or a single television channel. This arrangement was adopted by the C.C.I.R. in 1956.

To be read on the 7th December 1959

Characteristics and protection of semiconductor rectifiers *Paper* 3135U: *Part A*

D. B. CORBYN, B.SC.(ENG.), *and* N. L. POTTER, B.SC.(ENG.)

THE authors describe the probable sphere of application of the monocrystalline semiconductor rectifier and state the problems which must be solved to ensure reliable operation in both normal and abnormal conditions.

The basic characteristics of the rectifiers are studied. A description is given of the test methods required to establish the characteristics.

Operation is examined in normal conditions and during faults and overloads, and protection needs are deduced.

The properties of h.r.c. fuses are discussed, and by consideration of the rectifier properties and operating conditions the requirements are derived for the special fuses necessary. These special fuses provide a basis for a protective system enabling full use to be made of the new rectifiers.

An account is presented of the practical application of these special fuses showing how different forms of protection can be co-ordinated to ensure satisfactory operation of the rectifiers in different conditions for a wide variety of duties.

To be read on the 10th December 1959

MONOGRAPHS

Optimization of a class of non-linear filters *Monograph* 344E

J. K. LUBBOCK, M.A., B.SC.(ENG.)

AN optimum linear filter in the mean-square-error sense is no better than the optimum attenuator if there is no dissimilarity between the spectral densities of the signal and the noise. However, non-linear filters can use more statistical information about the signal and noise so that although they both possess the same spectral densities a non-linear filter may be able to introduce a significant improvement in the mean-square error (i.e. it can do better than the optimum

attenuator). For this reason the use of a non-linear filter in certain circumstances may well justify the greater difficulties encountered in its optimization and physical realization.

The class of filters considered by the author may be defined by a general expression relating output to input:

$$y(t) = \sum_{r=1}^{R} \int_0^\infty \omega_r(\tau)\theta_r[x(t-\tau)]d\tau$$

An almost routine procedure is proposed whereby the optimum set of weighting functions $\omega_r(\tau)$ can be determined given either long enough samples of the combined input and the signal or sufficient statistical information about their characteristics. Some worked examples demonstrate that:

(a) A significant improvement in mean-square error is possible even in the condition when the signal and noise possess the same spectral densities

(b) The class of non-linear filters under consideration can be optimized unhindered by the need to evaluate difficult integrals

(c) Although the physical complexity of the filter increases rapidly with value of R the mean-square error may converge quickly to an asymptotic value as R is increased; in one example the performance was found to be within about 5% of the asymptotic value with $R = 2$.

Optimum ratio of copper losses and iron losses for a transformer with variable load *Monograph* 348 S

G. S. BROSAN, PH.D., B.SC.(ENG.), *and* D. O. BISHOP, PH.D., B.SC.(ENG.)

WHEN a power transformer is loaded so that it is operating at maximum efficiency the copper losses are equal to the iron losses.

With most transformers the load varies greatly over a load cycle, and the optimum ratio of copper losses and iron losses calculated on the assumption of constant load for a given period can only be at least a rough approximation.

The authors suggest a method of obtaining a more accurate optimum ratio in cases where the load variation of the transformer can be estimated in advance.

Note on the optimum design of non-uniform transmission lines *Monograph* 349E

L. SOLYMAR

THE optimum design of non-uniform transmission lines for a given bandwidth is discussed. The shorter the line the more violently its characteristic impedance varies. The concept of complexity of this characteristic impedance function is introduced, and a design procedure is suggested for minimizing the complexity.

Numerical examples are given to illustrate the method. It is possible to design tapers even shorter than the Chebyshev type.

The method is capable of further extension.

PLANNING MEETINGS

THE Federation of American Societies for Experimental Biology has undertaken to develop and test machine methods of scheduling the thousands of scientific papers read at large meetings of professional and academic societies. The resulting techniques are expected to reduce greatly the magnitude and complexity of the programming process.

It is hoped by this means to improve communications between scientists by increasing the effectiveness of meetings. A trial of machine-based methods will be made in planning the April 1960 meeting of the Federation. Both the mechanical and the traditional systems will be used, and the two resulting programmes will be compared and evaluated. At the Federation's 1959 meeting 2383 ten-minute papers were scheduled for 235 separate sessions over five days.

Plans for the machine system call for the development of a hierarchal subject classification of papers. Coding sheets will be given to authors who will classify the subject-matter of their individual papers.

The papers will then be automatically grouped and assigned to sections.

BENELUX SECTION OF THE I.R.E.

THE first meeting of the newly formed Benelux Section of the Institute of Radio Engineers was held on the 3rd October 1959 in Rotterdam. Talks were given on the radio and navigational equipment of the s.s. *Rotterdam* to which a visit was paid in the afternoon. 75 members and guests attended the meeting, and it is understood that the section has some 90 members.

The Isotope School—Wantage Radiation Laboratory

AFTER eight years at Harwell the Atomic Energy Research Establishment's Isotope School has been established in new buildings at the Wantage Radiation Laboratory.

The purpose of the school is still to give practical and theoretical instruction in the use and safe handling of radioisotopes, but its scope has widened since its inception and is now likely to increase still further.

At Harwell the school was accommodated in converted buildings. The new premises at Wantage have been specially designed to meet its requirements. Design work and construction supervision were carried out by the authority's development and engineering group.

It is a single-storey brick and timber structure covering about 11000 ft^2.

It includes a lecture room to seat 50 people, a students' room, a teaching laboratory, counting rooms in which the activity of radioisotopes can be measured, and a variety of laboratories for special purposes.

The school is equipped to accept 36 students for its basic courses, but it will be possible to arrange for smaller specialized groups to be accommodated at the same time.

The 2000th student to attend the school since it opened in April 1951 completed in October 1959 the first short course for senior executives in industry to be held in the new premises. This course demonstrates some of the ways in which radioisotopes and radiation can help with industrial problems.

The 1960 programme includes five general courses and two short courses in radiological protection. As well as this advanced lectures in chemistry and radiobiochemistry are planned, and there is to be a course for medical men. Other special series are for analytical chemists and water chemists, and there will be a special course in autoradiography. If there is adequate demand there will be a further advanced physics course and a course on the use of high-activity radiation sources as well as short orientation programmes for senior executives.

SOME RECENT BOOKS

K. W. CATTERMOLE

TRANSISTOR CIRCUITS

LONDON: HEYWOOD. 1959. 442 PP. £3 10S.

ON p. 37 the author remarks 'It is difficult to say anything that will not speedily become out of date', and this volume indeed illustrates the problem of writing about a rapidly developing subject. Although it is dated 1959 not many of the 170 references are later than 1956, while the prominence given to point-contact transistors and the remarks made about the properties of available junction transistors indicate that much of the text was probably written in early 1957.

Nevertheless this is probably the most comprehensive work on transistor circuits to have been written by a single author. The single authorship has resulted in uniformity of style, avoidance of duplication and a general coherence usually lacking in the combined work of several authors. The literary style is unusually good: jargon is almost completely absent, but Cattermole makes good use of a vocabulary wider than that of the average technical writer and the reader hardly ever needs to reread a sentence in order to grasp its meaning.

There is throughout a nice balance between mathematical proof and verbal explanation. Almost equal space is given to transistor fundamentals, linear circuits and non-linear circuits, and very little is omitted which was important at the time of writing. No attempt is made to give numerical values to the circuits, and the section on applications is quite brief. The book is not for those who expect to be spoon-fed with fully detailed circuits, but it is to be recommended to anyone wishing really to understand transistor circuits of almost any type.

A. C. GILLIE

TRANSISTORS

NEW YORK: PRENTICE-HALL. 1959. 262 PP. £4 1S.

AN author of an elementary book seeking to avoid serious analysis can easily underestimate the task of minimizing the qualifying statements which are needed to the elementary generalizations in order not to mislead the reader about the more complex parts of the subject. This work is perhaps freer than some of such qualifications, but it contains many —far too many—inaccuracies that no qualifications would rectify.

Thus (p. 1) we are told that the application of electric potential frees electrons in a material and (p. 51) that highly purified germanium is an insulator (whereas it has a conductivity of about 0·02 mho/cm at room temperature). Worse follows for (p. 53) diffusion of electrons in a crystal is said to be due to mutual repulsion. There are many ambiguous or insufficient statements; thus 'the increase in resistance (of copper) is a small fraction of an ohm per degree rise in temperature'. Elsewhere we read that 'the common base configuration curves use the base current as one of the variables, and since this current is small, it cannot be specified within a fair degree of accuracy'.

The descriptions of some of the elementary circuits are not entirely without merit, but space is wasted on the point-contact transistor and some other devices.

It is difficult if not impossible to recommend the volume to any engineers, whether they be newcomers to the subject or have some prior knowledge. Anyone responsible for teaching the subject and with plenty of time to spare might learn something from the author's approach provided that he is ever on the look-out for mistakes.

MAX KNOLL

MATERIALS AND PROCESSES OF ELECTRON DEVICES

BERLIN: SPRINGER-VERLAG. 1959. 484 PP. £5 13S. 6D.

THIS is partly based on the book by Knoll and Espe 'Werkstoffkunde der Hochvakuumtechnik' (1938). It is intended for physicists and engineers concerned with vacuum technique and the design and construction of electron tubes or semiconductor devices.

It is essentially a reference volume in which all the materials likely to be used in electron devices are examined. The graphs, diagrams and photographs are numerous and their quality is excellent. Intelligent use is made of colour, e.g. to show stress patterns in glass. To reinforce the text there are no less than 2300 references including many patents.

The chapters on materials cover high-melting-point alloys, base metals, alloys, glasses and ceramics, semiconductors and organic materials, gases and vapours.

In general these are dealt with in great detail, the physical and chemical properties, methods of manufacture and technical applications being fully described. However the author obviously prefers some metals to others. All of 27 pp. are devoted to tungsten and only eight to germanium, but there are 180 references to germanium.

Most of the more important manufacturing processes are discussed, valves being studied more closely than solid-state devices.

This is a major work which can be highly recommended.

H. W. KATZ (*Editor*)

SOLID STATE MAGNETIC AND DIELECTRIC DEVICES

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 542 PP. £5 8S.

TEN authors collaborate in this welcome compilation of previously scattered information on devices using the magnetic and dielectric (but not semiconducting) properties of solids. A device, like the elephant, is more easily recognized than defined, but its nature will emerge from what follows.

Rather elementary chapters on electric and magnetic

polarization precede a mathematical discussion of electro- and magneto-strictive elements and the behaviour of circuits containing them. Non-linear behaviour arising from electric and magnetic hysteresis is introduced via ferrite cores and tapes and square-loop ferroelectrics. Analysis of non-linear circuits is touched on.

The design and circuitry of (mainly) low- and audio-frequency linear and non-linear components are covered in sections on magnetic recording, transducers and filters, digital techniques, and two dealing with a miscellany such as magnetic and dielectric amplifiers, small transformers and chokes, frequency convertors, and ferrite aerials. A chapter each is given to the microwave properties of ferrites and to some less usual measuring techniques needed with non-linear materials.

Some cursory treatment is inevitable in so wide a field but should not have extended to definitions. A substance is pyro- not ferro-electric if it (merely) has spontaneously polarized domains. Ferroelectric domains must be capable of reorientation. That 'the conditions . . . for ferro-electricity are . . . sufficient . . . for piezo-electricity' is true but misleading. They are much more than sufficient. The immunity of liquids from the Clausius–Mossotti catastrophe depends not on their random molecular orientation but on more recondite considerations.

To an English reader at least it may seem odd to be given polarization theory from first principles but credited with a prior working knowledge of vector and matrix algebra. Also odd is 'criteria' (p. 152) as a singular noun.

These matters may be defects of multiple authorship. They do not seriously detract from the value of the book which will be greatest to the postgraduate engineer entering the field of design of these devices.

I. R. MAXWELL, P. W. MUMMERY and P. SPORN (*Editors*)

THE ECONOMICS OF NUCLEAR POWER—VOL. 2

PERGAMON PRESS. 1959. 419 PP. £5 5s.

VOL. 1 was reviewed in the September 1957 *Journal* and consisted largely of papers presented to the first international conference on the peaceful uses of atomic energy (Geneva 1955). Three years later the second Geneva conference was held, and this volume contains 27 of the papers grouped under four heads.

The first group considers the world demand for electricity and the part which nuclear power could play in meeting this demand, particularly in the underdeveloped countries. The Figure reprinted, taken from a paper by Mayer, shows electricity consumption in the six continental areas projected over two ten-year periods. European consumption, at present slightly below that of North America, is expected to exceed it in 1965 and to be very much greater in 1975.

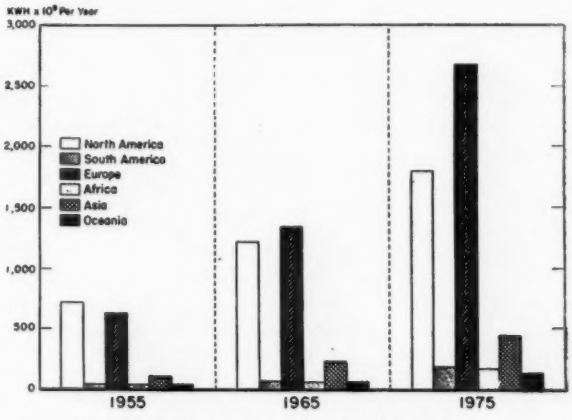
The second group deals with nuclear-fuel supply and costs. World resources are briefly surveyed, and the economics of uranium mining are discussed in detail.

The third and largest group studies the economics of nuclear power generation and interrunning with steam, hydroelectric and pumped-storage systems. Based on United Kingdom experience the earlier estimate of over-all cost of nuclear power, 0·43–0·59d./kWh, has been modified to 0·59–0·81d./kWh, the difference being chiefly due to a change in the assumed rate of interest on capital from 4 to between 5 and 6%.

The final group examines nuclear-power programmes with papers on the position in Canada, France, India, Italy, Japan, Poland, the United States and the Soviet Union. No attempt has been made to integrate these papers or to summarize the world position.

The work concludes with a subject index, a list of all the papers and sessions of the second Geneva conference which relate to economics, and a contents list of the previous volumes in the series.

As in Vol. 1 there is more sign of editors than of editing: for example the title page consists of three lines the first of which describes the subject as nuclear power and the second as nuclear energy while the third reads 'including administration and law'. The book contains nothing on the latter topic which is treated in another series. Such criticisms notwithstanding, this is a useful selection of papers on the economic aspects of nuclear generation which many advanced students and practising engineers will be glad to have in so convenient a form.



An analysis of world power consumption by continent

L. B. LOEB

STATIC ELECTRIFICATION

BERLIN: SPRINGER-VERLAG. 1958. 240 PP. £4 (approx.)

ALTHOUGH the oldest form of electrical phenomenon known, static electrification has remained for most electrical engineers a matter for school exercises. But for some it has become a subject of major importance, either because of the hazards it can create as in explosions or by reason of its application to serve a useful purpose. In both cases a knowledge of the basic physical phenomenon is necessary to deal with the difficulties encountered.

This work aims to provide a critical review of static-electrification processes in the light of present-day knowledge. It is inevitably written in a précis style in part and gives a good

selection of what are considered the most important references rather than a more complete list such as would be found in a source book. It furnishes a compact review for the student and a good starting-point for specialists in a variety of fields who meet electrification problems.

It is divided into five chapters, namely Electrolytic processes, Volta potentials, Spray electrification, Contact electrification, and Other processes—the last including reference to gaseous ionization and the lightning-stroke.

That each specialist reader would like to find more space devoted to his own interests is to be expected, but even he will be likely to profit from the correlation attempted by the author over the wider ambit.

G. J. MURPHY

CONTROL ENGINEERING

NEW YORK: VAN NOSTRAND. 1959. 385 PP. £2 16S.

THE title is rather too broad to indicate the content which would be more accurately described as an introduction to the analytical theory of servomechanisms. Within this field a fairly broad band of topics is discussed at an intermediate level accessible to most engineers and engineering students.

The material on time and frequency response of typical transfer functions, stability, root loci, simple compensating methods, elementary statistical considerations, describing functions and servo-component characteristics is now standard provision in a work on this subject.

Other matters often omitted from the more elementary texts, for instance carrier systems, sampled data, phase-plane methods and the treatment of dead time, are dealt with in a simple and lucid fashion. The account of multiloop systems however is so short as to be negligible and could well have been extended.

The book is clearly written with a commendable absence of padding and a variety of worked examples and problems. In short it is a worthy addition to the rather large number of textbooks on the subject, distinguished mainly by the inclusion of a wide range of topics at a generally useful level in one volume of moderate size.

G. W. SMITH and R. C. WOOD

PRINCIPLES OF ANALOG COMPUTATION

McGRAW-HILL. 1959. 234 PP. £2 18S.

J. N. WARFIELD

INTRODUCTION TO ELECTRONIC ANALOG COMPUTERS

LONDON: PRENTICE-HALL. 1959. 175 PP. 30S.

SMITH and Wood are to be congratulated on producing a refreshing and extremely useful volume. Designed primarily for users or intending users of analogue computers it contains much information on problem planning and programming and on techniques for simulation of linear systems including various circuits for dead-time simulation.

Chapters dealing with the use of biased-diode circuits, implicit-function techniques, and arbitrary-function generators bring the text well up to date on non-linear computing, an important aspect which has been widely ignored hitherto. Accounts of the main components and basic lay-out of an analogue computer and a description of the conventional operational amplifier unit are given. The book should prove of great service to a wide range of readers such as undergraduates, control engineers, and mathematicians.

In the work by Warfield simple accounts are given of the basic linear and non-linear computing elements to be found in analogue computers, and the types of linear and non-linear differential equations with which the machine can deal are examined. The main chapters consider signal-flow graphs and show how these may be simply used to break down a system transfer function into a form permitting 'simulation' of the system.

In using the word 'simulation' here the author is open to some criticism since the process described, while it is certainly useful in obtaining a computer set-up having a given transfer function, is likely to prove of little value to the control engineer in building up the true simulation of a practical system. A practical system is usually non-linear, and a simulation is efficacious largely because of the direct correspondence of components in the practical system with computing units which represent them in the simulation.

Certain unusual and oblique aspects of the subject are presented in the remainder of the book including sections devoted to the philosophy and practice of checking results, systems engineering, and an introduction to Z-transforms.

T. C. G. WAGNER

ANALYTICAL TRANSIENTS

NEW YORK: JOHN WILEY. LONDON: CHAPMAN AND HALL. 1959. 202 PP. £3 10S.

IN all treatments of the application of mathematical techniques to engineering the author has to decide on a suitable level of rigour. Too much rigour may not only make progress difficult but can in fact bewilder and even revolt the most assiduous reader and lead to charges of pedantry. Too little rigour, albeit for the sake of rapid progress, may lead to an inadequate understanding of the application of the author's methods to new problems.

Prof. Wagner here makes a bold attempt to strike a balance in the application of classical mathematical analysis to topics in electrical networks. There is a sound grade of rigour which is between that adopted in most volumes on circuit analysis and the more exacting domain of the pure mathematician. The text presupposes an elementary knowledge of network analysis and an acquaintance with the differential and integral calculus.

There are seven chapters and an index. Chapter 1 is an introduction to the Laplace transform, chapter 2 gives a detailed account of the standard methods of network analysis, and chapter 3 discusses initial transient behaviour. There is a consideration of Fourier analysis (including Gibbs's phenomena) in chapter 4 while chapter 5 examines stability problems with application of the theorems of Sturm and Routh (on polynomial roots), Cauchy (argument principle) and Nyquist. Chapter 6 on additional properties of the Laplace transform is an excellent instance of the application of rigour. Chapter 7

is devoted to a study of complex-variable theory and the inversion integral of the Laplace transformation.

There are examples to be solved at the end of each chapter. The book would benefit by the inclusion of the answers to these and of a list of notations with page references to their first usage. The printing is of a high standard.

The reviewer recommends the work to all serious students of electrical-network theory and in particular to those intent on acquiring a sound knowledge of the basic mathematical techniques.

J. N. SHIVE

THE PROPERTIES, PHYSICS AND DESIGN OF SEMICONDUCTOR DEVICES

NEW YORK: VAN NOSTRAND. 1959. 487 PP. £3 13S.

THIS book has its origin in a course of lectures included in a graduate-level training programme for newly recruited technical staff at the Bell Telephone Laboratories. Furthermore the author is well known for his original contributions to the subject so the reader may rest assured that the treatment is accurate and up to date.

The first half is devoted to an account of the nature, properties, behaviour and uses of semiconductor devices. Although information on rectifiers and transistors naturally occupies a great deal of the text there are chapters on thermistors and semiconductor photocells, and many of the less known devices such as solar batteries are described. The whole forms a remarkably complete account of the ways in which semiconductors are now being used.

In the second half the physical theory underlying the behaviour of semiconductor devices is set out. Here the chapter headings have a familiar ring—band theory, conduction mechanisms, hole and electron statistics, and so forth—but the treatment is refeshingly original since the author manages to convey a physical picture which is far from superficial without recourse to any appreciable amount of mathematics.

This is an excellent work which should be widely read.

**Denotes that the publication is also in the Lending Library. The publications cannot be bought through The Institution; the publishers and the prices are given only for the convenience of members*

BOOKS

BURSTYN, W. 621.3.066.6

Elektrische Kontakte und Schalt-Vorgänge (Electrical contacts and processes) **4th edition***

Berlin: Springer-Verlag, 1956. pp. vi, 110. 23 × 15cm. 15s. 5d.

Deals with switching of d.c. and a.c. circuits and associated contact phenomena.

GOODMAN, L. L. 658.2

Automation today and tomorrow*

London: Newman Neame, 1959. pp. vi, 158. 22 × 14·5cm. £2

The first part of this book gives a concise indication of applications of automation and control and of important technical considerations allied to the subject. The second part is an extensive bibliography covering the technical, social and economic aspects of the automatic factory. An author and a subject index are included. Reviewed in October 1959 *Journal*, p. 603.

SIMON, A. 539

An introduction to thermonuclear research

London: Pergamon Press, 1959. pp. ix, 182. 22 × 14cm. 35s.

An expansion of lectures given in 1955 to physicists, chemists and engineers at the Oak Ridge Laboratory. Deals with basic problems of controlled fusion and is intended as a qualitative explanation of the physical equations involved rather than as a rigorous treatment.

SLOVENSKA AKADEMIA VIED 92(STO)

Aurel Stodola 1859–1942

Bratislava: Slovenska Akademia Vied, 1959. pp. 154. 21 × 13cm. n.p.

Commemorative volume of a pioneer in the development of the steam turbine.

WAIT, J. R. 621.396.67

Electromagnetic radiation from cylindrical structures*

London: Pergamon Press, 1959. pp. ix, 200. 22 × 14·5cm. £2 10s.

A theoretical treatment of electromagnetic waves on and near cylindrical surfaces in connection with the behaviour of flush-mounted antennae used in aircraft and missiles. Reviewed in October 1959 *Journal*, p. 607.

LIBRARY ACCESSIONS

ZINKE, O., and BRUNSWIG, H. 621.317.029.5

Hochfrequenz-Messtechnik (High-frequency measuring technique) **3rd edition**

Stuttgart: Hirzel, 1959. pp. xiv, 324. 23·5 × 16cm. DM24.80

Includes methods of measuring modulation and the characteristics of antennae.

Hochfrequenz-Messgeräte (High-frequency measuring apparatus)

Stuttgart: Hirzel, 1959. pp. viii, 50. 23 × 15·5cm. DM9.60

A supplementary volume comprising a classified list of apparatus commercially available. It gives technical specifications and the names of the makers, who are mainly German and American.

OTHER PUBLICATIONS

AUTOMATIC TELEPHONE AND ELECTRIC CO.

Mosaic diagrams. Engineering Bulletin 2308. Issue 4

London and Liverpool: Automatic Telephone and Electric Co., 1959. pp. 14. 27·5 × 21cm. n.p.

INGENIEUR-ARCHIV

Festschrift Richard Grammel zum 70 Geburtstag am 3 März 1959 Edited by K. V. Sanden

Berlin: Springer-Verlag, 1959. pp. vii, 371. 28 × 20cm. DM52

INTERNATIONAL ELECTROTECHNICAL COMMISSION

International electrotechnical vocabulary, group 31, signalling and security apparatus for railways. 2nd edition

Geneva: United Nations, 1959. pp. vii, 46. 29·5 × 21cm. 8 Swiss francs

INTERNATIONAL TELEGRAPH AND TELEPHONE CONSULTATIVE COMMITTEE (C.C.I.T.T.)

Red book—Vol. 2. Special assembly Geneva 22–27 September 1958, 24 November 1958

Geneva: International Telecommunications Union, 1959. pp. 374. 25 × 17·5cm. £2

Library accessions (continued)

INSTITUTION OF POST OFFICE ELECTRICAL ENGINEERS

Recent developments in line transmission systems by R. H. Franklin and M. B. Williams. Paper No. 213

London: Institution of Post Office Electrical Engineers, 1958. pp. 25. 27·5 × 21 cm. 2s. 6d.

MÜLLER-HILLEBRAND, D.

Static electricity and explosions: explosion venting

Stockholm: *Teknisk Tidskrift*, 1959. pp. 22. 29 × 21 cm. n.p.

UNITED STATES DEPARTMENT OF COMMERCE

OFFICE OF TECHNICAL SERVICES

NEL reliability bibliography. Supplement 2 Compiled by W. E. Jorgensen, I. G. Carlson and C. G. Gros

Washington: United States Department of Commerce, Office of Technical Services, 1958. pp. 85. 26 × 20 cm. $2.25

UNITED NATIONS

ECONOMIC COMMISSION FOR EUROPE

Rural electrification—Vol. 3

Geneva: United Nations, 1958. pp. ii, 176. 28 × 21·5 cm. 11s.

The state of rural electrification in Europe in 1957

Geneva: United Nations, 1959. pp. 61. 28 × 21·5 cm. 3s.

SWEDISH STATE POWER BOARD

The Lasele power plant by Sten Elfman

Stockholm: Swedish State Power Board, 1958. pp. 16. 30 × 21 cm. n.p.

The Ligga hydro-electric power plant by J. F. Hagrup

Stockholm: Swedish State Power Board, 1959. pp. 16. 30 × 21 cm. n.p.

Elections and transfers

The following elections and transfers approved by the Council are effective from the 9th October 1959

ELECTIONS

Graduates

BALMER, Leslie, B.SC.
BEADMAN, Roger, B.ENG.
BLYTHE, William Henry, B.SC.
BROWNLIE, Robert
COCKLE, Anthony Laurence
COOPER, Flt.-Lt. Peter Alan, B.SC., R.A.F.
COPPING, Brian
CRESSWELL, Charles James
DUCKWORTH, James, B.SC.
FINNIMORE, Benjamin Keith, B.A.
GITTINS, Capt. Gerald Wyn, B.A., R.SIGNALS
GOLD, Robert Geoffrey, B.SC.
GREEN, Leslie
GRIFFITHS, John Peter, B.A.
GRISLEY, Ronald Peter
HALESWORTH, Brian Francis
HESSION, Enda, B.ENG.
HITCHINGS, Pilot Officer Gwynne Mason, R.A.F.
JACKSON, John Keith, B.ENG.
JACKSON, Michael Robert, B.A.
JOHNSON, Alan
KELLEHER, Michael Anthony, B.SC.
KNIGHT, Geoffrey
LACKO, Gabor
LATHAM, George
McLAGAN, Angus, M.SC., B.E.
MALIK, Usman Akhtar, B.SC.
MANNING, Eric George
MONIR, Mohammad, D.F.H.
MURRAY, John Archibald, B.SC.
MUSA, Erdoghan Hussein
O'DONNELL, Terence Robert
OLTMANN, Gottfried Wilhelm, B.SC., B.SC.(ENG.)
OWEN, William John
PAGE, Michael Ian
PEARCE, Walter Arthur
PLUMMER, Alan John Regson, DIP.TECH.(ENG.)
POWELL, David Norman
POWELL, Frank Sutherland
RAMSAY, Walter Ronald
REES, Flt.-Lt. Gareth Huw, B.SC., R.A.F.
ROSE, James Arthur, D.L.C.
SHAH, Amritlal Nemchand, D.F.H.
SHULMAN, Henry Edward
SOTO, Sergio Meza
TAGARE, Vasant Madhav, B.SC.
TAYLOR, Anthony Peter, B.SC.
THEODOSSIADES, Charalambos Georgiou, D.F.H.
THOMAS, Gordon
TODD, Thomas Robson
UNDERWOOD, Ronald Thomas
YOUNG, David John, B.A.

Students

ABAYARATNA, Asoka Tikiri Banda
ADNITT, John Robin
AMARASINGHE, Dharmasiri, B.SC.
ANSARI, Shafiq Ahmad
BACKHOUSE, John Arthur
BANFORD, Richard William
DE BEER, William Allan
BHATTACHARJEE, Protip Kumar, B.E.E.
BLOCKSIDGE, Dennis Thomas
BOOTH, Roy Sims, B.SC.
BOSWORTH, John David
BRAITHWAITE, Robert
BROWN, James Patrick
BROWN, Roy William
CARROLL, John
CHARLTON, Ian John Austin
CLAXTON, Peter Arthur John
CONNELLY, Ralph
CURTIS, Thomas Anthony
DUMELOW, Denis William
ELLIOTT, Ernest John Clifford
ELLIS, Gordon Henry
ESSAM, Lionel John
FONSEKA, Hewafonsekage Cyril Dunstan
FURBEY, Geoffrey David
GAN, Seck Liang
GARRETT, John Mansell, B.SC.
GATES, Geoffrey Phillip
GRACE, Michael John
HAWKINS, John Frederick
HEDGES, Allan Frank
HENDERSON, David Harry
HOLLAND, Ian Malcolm
JONES, Edwin Brian, B.SC.(ENG.)
McVEA, Robert James
MAGGS, Dennis George, B.SC.
MAHMOOD, Ali Morshed, B.SC.
MALHOTRA, Rajendralal Vasudev
MANICKAVASAGAR, Selliah
MATTHEWS, Paul Stuart, B.SC.
MAXTED, Victor Wessels
MAZUMDER, Ranjit Basu
NAYLOR, Eric Michael
NIELD, Anthony
OKUNRINBOYE, Olufolarin
PAGEDAR, Anilkumar Madhavrao, B.E.
PANIKKER, Ramesh Nilkanda
PATERSON, John Hillgrove
PULUKKODI, Ramya Sena
RAYMOND, Oliver John
ROBERTSON, David Lewis, B.SC.
ROSS, Douglas Stuart
SIMMS, William Robert
SIMPSON, Robert Terence
STAGG, Kenneth Albert
STEADMAN, David Rosslyn Ayton
SUHAIL, Ahmed Marzook Mohamed
TAGGART, John Colin
TEWARY, Jugal Kishore
TIBBETTS, Owen Darrell
TOMLINSON, Peter George
TOMPSETT, Michael Francis
WELLS, David
WIKRAMANAYAKE, Nihal
WILDE, James Russell

TRANSFERS

Student to Graduate

BAKKENIST, Peter Allen, B.SC.
BALDRY, Brian Derek, B.SC.
BRIGGS, David, B.SC.
BULL, John Trevor
COLES, David George, B.SC.
COMBER, Christopher Edward, B.SC.
COUSINS, John Philip
DHANABALASINGAM, Seenivasagam
EDMUNDSON, John, B.SC.
GILL, Ujagar Singh
GLOVER, Adrian Arthur, B.ENG.
GODBER, Alan Sydney, B.SC.
GOLDIE, Samuel David, B.SC.
HORROCKS, Michael John, B.SC.(ENG.)
JEFFERS, David Edmund, B.SC.(ENG.)
JONES, Nicholas, D.F.H.
LAMBERT, Eric, D.L.C.
LAWRENCE, Barry Reginald, B.SC., B.E.
LAY, Peter John, B.SC.(ENG.)
MACKENZIE, John Ross, A.H.-W.C.
MALLALIEU, John Patrick
MORGAN, Keith William
O'BRIEN, Michael Thomas, B.E.
ROBERTSON, Philip Pearson, A.H.-W.C.
SCHOFIELD, John Richard Garrs, B.SC.
SHENTON, Roy Trevor
SHEPHERD, John Teesdale
SLIGH, Alastair David Moffat, B.SC.
TYLER, Brian, B.SC.
WAGHORN, Brian Norman
WALTON, Robert Alfred, B.SC.TECH.
WHITE, Alan Graham
WRAPSON, Alan Ian
YOUNG, Thomas Ralston

District Meetings

ARRANGEMENTS for District Meetings in November and December other than in the area of a local Centre

November 1959

READING (at the George Hotel, King Street at 7.15 p.m.)

23 *Monday* R. C. M. BARNES, B.SC.(ENG.) 'An introduction to electronic computers'

December 1959

MAIDSTONE (at Maidstone Technical College at 6.30 for 7 p.m.)

7 *Monday* W. IMRIE SMITH 'An analytical approach to industrial lighting'

Forthcoming events at Savoy Place

ALL meetings are held at Savoy Place beginning at 5.30 p.m. (tea at 5 p.m.) except where otherwise stated. The nature of the meeting is indicated by the following key:

ED EDUCATION DISCUSSION CIRCLE
E ELECTRONICS AND COMMUNICATIONS SECTION
I INFORMAL
M MEASUREMENT AND CONTROL SECTION
MED MEDICAL ELECTRONICS DISCUSSION GROUP
O ORDINARY
S SUPPLY SECTION
U UTILIZATION SECTION

After each paper that has now been published is added the month when a synopsis appeared in the *Journal* under 'Papers and monographs published individually this month', i.e. about the time when the paper was published as a separate. A paper that has not yet been published will be available at least ten days before the meeting at which it will be read. The full list of London meetings is given in the meetings card

November 1959

ED **20** *Friday* T. SIKLOS, DIPL.ING., will open a discussion on 'The Ordinary National Certificate—a new look'* (at 6 p.m., tea at 5.30 p.m.)

E **25** *Wednesday* R. L. SMITH-ROSE, C.B.E., D.SC., PH.D. Lecture on 'Radio aspects of the International Geophysical Year'†

O **26** *Thursday* T. R. MANLEY, B.SC., K. ROTHWELL *and* W. GRAY 'The application of low-pressure resins to some high-voltage switchgear designs' (paper 2835S) *synopsis:* see p. 660

December 1959

ME **1** *Tuesday* L. ESSEN, O.B.E., D.SC., PH.D., J. V. L. PARRY, M.SC., *and* J. MCA. STEELE, B.SC.(ENG.) 'Frequency variations of quartz oscillators and the earth's rotation in terms of the N.P.L. caesium standard' (paper 3002M) *synopsis:* August 1959 (Joint Meeting)

O **3** *Thursday* C. B. B. WOOD *and* I. J. SHELLEY. Lecture on 'The transmission of news film over the transatlantic cable'‡

MED **4** *Friday* N. SHEPPARD, M.A., PH.D., *and* R. E. RICHARDS, M.A., D.PHIL., will open a discussion on 'Nuclear magnetic resonance'* (at 6 p.m., tea at 5.30 p.m.)

E **7** *Monday* B. B. JACOBSEN, B.SC.(ENG.) 'Frequency patterns for multiple-radio-channel routes' (paper 3033E) *synopsis* see p. 660

S **9** *Wednesday* J. R. HILL, B.SC.(ENG.), A. HUNT, B.SC.(ENG.), W. J. JOYCE, B.SC., *and* D. H. TOMPSETT, B.SC.(ENG.) 'Field suppression of turbo-alternators' (paper 3161S) *synopsis:* see p. 660

U **10** *Thursday* D. B. CORBYN, B.SC.(ENG.), *and* N. L. POTTER, B.SC.(ENG.) 'The characteristics and protection of semiconductor rectifiers' (paper 3135U) *synopsis:* see. p. 660

I **14** *Monday* P. P. ECKERSLEY will open a discussion on 'Why hi-fi?'*

M **15** *Tuesday* D. TAYLOR, M.SC., PH.D., will open a discussion on 'Data-handling problems in atomic installations'†

E **16** *Wednesday* CAPT. W. H. LEECH, O.B.E., D.S.C. Lecture on 'The laying of submarine cables'†

ED **17** *Thursday* PROF. H. DINGLE, D.SC., will open a discussion on 'The presentation of the history and philosophy of science'* (at 6 p.m., tea at 5.30 p.m.)

* No advance information will be available and no Press report will be permitted
† An abstract will be available in advance
‡ No advance information will be available

British Nuclear Energy Conference

DETAILS of three forthcoming meetings of the British Nuclear Energy Conference are given below. Papers and discussions on the applications of nuclear energy and ancillary subjects are published in the quarterly *Journal of the British Nuclear Energy Conference*. The annual subscription payable by members of The Institution who wish to receive the *Journal of the B.N.E.C.* regularly is 30s. post-free. Single copies are available at 7s. 6d. each

1959

NOVEMBER 24 *Tuesday* (2.30 p.m.)

Sponsoring society: The Institution of Chemical Engineers

Place of meeting: The Royal Institution, Albemarle Street, London W.1

SYMPOSIUM ON NUCLEAR ENERGY

SECOND URANIUM PRODUCTION PLANT AT SPRINGFIELDS R. C. Alexander, L. P. Shortis and C. J. Turner

PROCESSING OF URANIUM ORES AND CONCENTRATES TO PURIFIED URANYL NITRATE SOLUTION H. Page, L. P. Shortis and J. A. Dukes

FLUIDIZED-SOLIDS DRYWAY PROCESS FOR THE PRODUCTION OF URANIUM TETRAFLUORIDE E. Hawthorn, L. P. Shortis and J. E. Lloyd

PUMPING STUDIES ON AQUEOUS THORIA SLURRIES R. Murdoch and H. A. Kearsey

USE OF HYDROGEN AS A REACTOR COOLANT D. Bradley

Tickets may be obtained from the Secretary of The Institution of Chemical Engineers, 16 Belgrave Square, London S.W.1. The registration fee including afternoon tea and preprints is 10s. for members of constituent societies of the B.N.E.C. and 20s. for non-members

NOVEMBER 25 *Wednesday* (6 p.m.)

Sponsoring society and place of meeting: The Institution of Mechanical Engineers, 1 Birdcage Walk, London S.W.1

Thomas Hawksley lecture on EFFECT OF NUCLEAR RADIATION ON ENGINEERING MATERIALS A. H. Cottrell

Tickets may be obtained from the Secretary of The Institution of Mechanical Engineers

DECEMBER 15 *Tuesday* (5.30 p.m.)

Sponsoring society and place of meeting: The Institute of Marine Engineers, 76 Mark Lane, London E.C.3

THE SHIELDING AND SECURITY OF MARINE REACTORS K. Maddocks

Contents of the current *Proceedings*

The date in italics is that of the Journal review, special article, or synopsis. Where given the date in capitals is the month in which a paper or monograph was published individually

PART A. POWER ENGINEERING (OCTOBER 1959)

See the Journal for October 1959, p. 613

PART B. ELECTRONIC AND COMMUNICATION ENGINEERING (NOVEMBER 1959)

H. HÄGGBLOM, TEKN.LIC. PAPER 3032E **The spectral density of the a.m. noise in reflex klystrons** *November 1959*

M. L. GAYFORD, B.SC.(ENG.). PAPER 2798E, FEBRUARY 1959 **High-quality microphones** *October 1959*

M. E. HAINE, D.SC., AND J. VINE, M.SC. PAPER 2800M, DECEMBER 1958 **An electron-trajectory tracer for use with the resistance network analogue** *June 1959*

T. S. ROBSON AND T. M. J. JASKOLSKI, DIPL.-ING. PAPER 3070E **High-power television transmitters for bands IV and V** *November 1959*

G. F. SWANN. PAPER 2816E, JANUARY 1959 **The field strengths required for the reception of television in bands I, III, IV and V** *June 1959*

B. G. PRESSEY, M.SC.(ENG.), PH.D., G. E. ASHWELL, B.SC., AND R. ROBERTS, B.SC. PAPER 3018E **Further studies of the deviation of low- and medium-frequency ground waves at a coast-line** *November 1959*

D. W. MORRIS, B.SC.(ENG.), AND G. MITCHELL, B.SC.(ENG.). PAPER 3078E **A multiple-direction universally-steerable aerial system for h.f. operation** *October 1959*

L. LEWIN. PAPER 3056E **A ferrite boundary-value problem in a rectangular waveguide** *September 1959*

Communicated discussion on **The performance of directive aerials in complex u.h.f. fields**

PART C. MONOGRAPHS (SEPTEMBER 1959)

See the Journal for September 1959, p. 557

ANNOUNCEMENTS TO MEMBERS

THE HOMES FUND

SUMMARY OF CONTRIBUTIONS RECEIVED TO 16TH OCTOBER 1959

	No. of contributors	£	*s.*	*d.*
£1000 and over	8	8685	0	0
£100 to <£1000	32	7181	3	0
£5 to <£100	895	9384	7	9
£2 to <£5	2180	6021	4	7
under £2	26478	13889	4	0
		£45160	19	4

APPOINTMENTS AND NOMINATIONS

WIRING REGULATIONS COMMITTEE, SUB-COMMITTEE NO. 7—CARAVAN INSTALLATIONS

On the nomination of the National Caravan Council the Council have appointed Mr. W. Athey and Mr. J. K. Pike to serve on the above sub-committee in place of Mr. Stephenson and Mr. Speed-Andrews.

ELECTRONICS AND COMMUNICATIONS SECTION COMMITTEE

On the nomination of the Royal Navy, the Army, and the Royal Air Force respectively the Council have appointed Capt. W. D. F. Muspratt, R.N., MEMBER, Col. R. G. Miller, M.A., MEMBER, and Group-Capt. D. W. Rowson, B SC.(ENG.), R.A.F., ASSOCIATE MEMBER, to serve on the above committee.

MEASUREMENT AND CONTROL SECTION COMMITTEE

On the nomination of the National Physical Laboratory the Council have appointed Mr. D. L. A. Barber, B.SC.(ENG.), to serve on the above committee.

OVERSEA REPRESENTATIVE

The Council have appointed Mr. G. R. Milne, B.SC., MEMBER, their Oversea Representative for New Zealand in succession to Mr. E. H. R. Green, C.B.E., M.SC., MEMBER, who has been appointed to represent New Zealand on the British Commonwealth Telecommunications Board.

CODES OF PRACTICE COMMITTEE FOR ELECTRICAL ENGINEERING (ELCP/–)

The Council have nominated Mr. F. H. Mann, MEMBER, as their representative on the above committee following the death of Mr. H. G. S. Peck, B.SC.(ENG.), MEMBER.

B.S.I. SUB-COMMITTEE ELE/4/10—CONNECTORS FOR PORTABLE APPLIANCES

The Council have nominated Mr. L. A. Corney, B.SC.(ENG.), ASSOCIATE MEMBER, as their representative on the above sub-committee in succession to Mr. H. Midgley, MEMBER.

B.S.I. SUB-COMMITTEE USM/2/6—LETTER SYMBOLS, SIGNS AND ABBREVIATIONS (ELECTRICAL ENGINEERING)

The Council have nominated Mr. G. E. Williams, B.SC.(ENG.), MEMBER, as their representative on the above sub-committee.

UTILIZATION SECTION COMMITTEE

On the nomination of the Admiralty, the War Office, the Air Ministry, the Ministry of Labour and National Service, and the Ministry of Works respectively the Council have appointed Mr. P. Smith, B.SC., MEMBER, Mr. C. L. Champion, B.SC., ASSOCIATE MEMBER, Mr. H. F. Innocent, MEMBER, Mr. S. J. Emerson, M.ENG., MEMBER, and Mr. P. McKearney, O.B.E., MEMBER, to serve on the above committee.

D.S.I.R. STANDING CONSULTATIVE CONFERENCE ON BUILDING RESEARCH AND DEVELOPMENT

The Council have nominated Mr. R. A. Marryat, B.SC.(ENG.), MEMBER, as their representative on the above conference.

FUEL EFFICIENCY AND POWER FOR INDUSTRY EXHIBITION—INSTITUTE OF FUEL ORGANIZING COMMITTEE

The Council have nominated Mr. H. V. Pugh, MEMBER, as their representative on the above committee.

MANCHESTER COLLEGE OF SCIENCE AND TECHNOLOGY, COURT OF GOVERNORS

The Council have nominated Sir Willis Jackson, D.SC., F.R.S., PRESIDENT, as their representative on the above court.

BRADFORD INSTITUTE OF TECHNOLOGY, ADVISORY COMMITTEE ON ELECTRICAL ENGINEERING

The Council have nominated Mr. A. J. Coveney, MEMBER, as their representative on the above committee.

UNION OF LANCASHIRE AND CHESHIRE INSTITUTES, ENGINEERING ADVISORY COMMITTEE

The Council have nominated Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D., MEMBER, as their representative on the above committee.

RETIRED MEMBERS: REVISION OF THE COUNCIL'S RULE

THE Council have occasion from time to time to consider the position of members who having retired from the profession still wish to retain their membership of The Institution, and in this connection they have revised their existing rule so as to embrace a wider range of such members. The new rule is as follows:

Any Corporate member or Associate who has reached the age of 60 and has retired from the practice of his profession or business may apply to the Council to waive or reduce his

future annual subscription depending on the length of his continuous membership as follows:

25 years	Full remission
20–24 years	Two-thirds reduction
15–19 years	One-third reduction

Members who pay reduced subscriptions will continue to receive the *Journal* without extra charge while those whose subscriptions are waived may continue to receive the *Journal* on payment of 10s. per annum. Parts A, B and C of the *Proceedings* will also be available at the usual rates.

A similar rule applies to Companions, but in this instance the governing age is 70 instead of 60.

It is left to the members concerned to make application to be brought within the rule.

CHRISTMAS HOLIDAY LECTURE

AT the invitation of the Council Mr. G. G. Gouriet, MEMBER, will deliver a Christmas Holiday Lecture entitled 'Colour television'. The lecture which is intended for boys and girls in the fifth and sixth forms will be given in the Lecture Theatre at Savoy Place on Wednesday, 30th December 1959 at 3 p.m. and will be repeated at the same time the following afternoon.

Schools in the home counties are being invited to apply for tickets, and a number will be reserved for members' children; members should apply for these by the 1st December 1959 stating for which afternoon they are required. As accommodation is limited members are asked not to accompany their children.

The following is a synopsis of the lecture:

Colour television was demonstrated by J. L. Baird as early as 1928, but it is only within the last ten years that practical means have been found for introducing colour into television broadcasting. For many years it was thought that colour television basically required three complete pictures to be transmitted, each in one of the three primary colours, in place of the single picture that is required for black-and-white television. Baird achieved this by arranging for the three pictures to be sent in rapid sequence in the same period of time that is required for a single black-and-white picture. Another method is to use in effect three separate television systems, one for each primary colour, and to transmit the three pictures simultaneously, combining them at the receiver to form a colour picture.

Neither of these methods is suitable for colour-television broadcasting mainly because they would use extravagantly a large amount of the radio-frequency spectrum which is needed for all forms of broadcasting and radiocommunication. A further disadvantage of these methods is that the colour-television signal is non-standard and will not provide the present-day receiver with a black-and-white version of the coloured scene. A programme broadcast in colour could therefore be viewed only by people possessing a colour receiver.

These disadvantages have been overcome by a very ingenious system which was first proposed in the United States. Instead of transmitting images in the three primary colours a standard signal called the 'luminance' signal is transmitted which describes the variations of light and shade in the scene. This is similar to a normal television signal. In addition two other signals are transmitted which together describe the colour, blue, yellow, mauve etc., and its purity, i.e. the extent to which it is a pale shade or a deep shade. These two signals are combined to form a single signal called the 'chrominance' signal.

This method offers some very important advantages. First a present-day receiver can receive the 'luminance' signal and will reproduce a normal black-and-white version of the coloured scene. A specially designed colour receiver however will receive both the luminance and chrominance signals from which a fully coloured picture may be reproduced on a special picture tube.

Secondly it is known that the human eye cannot see colour in very small areas so that it is unnecessary for the very fine detail in the picture to be reproduced in colour. It is thus possible to restrict severely the spectrum space occupied by the chrominance signal without affecting the sharpness of the reproduced image. In fact with this arrangement it is possible to transmit the complete colour-television signal using no more of the r.f. spectrum than is required for black-and-white television.

The lecture will be illustrated by demonstrations and lantern slides.

UTILIZATION SECTION MEETING 14TH JANUARY 1960

MEMBERS are asked to note that the following paper has been allocated for reading at the above meeting: 'The application of power transistors to the operation of gas-discharge lamps from direct-current supplies' by I. F. Davies, B.SC., and D. Dunthorne, B.SC.

CONVENTION ON THERMONUCLEAR PROCESSES

THE papers and discussions at the convention on thermonuclear processes will be published at the end of November 1959 in Supplement No. 2 to Part A of the *Proceedings*. This supplement—with its contents and index pages and in a semi-stiff cover—will be complete in a single issue. The prices (post-free) are £1 2s. 6d. to members of The Institution and £2 to non-members.

Copies may be obtained on application to the Secretary of The Institution.

CORRESPONDENCE

IN view of the heavy volume of correspondence received daily at the offices of The Institution it is of the greatest assistance when members in replying to letters received from the Secretary quote The Institution's reference number. This saves the time of the routing staff and ensures that a letter not only reaches the department concerned without delay but can be immediately linked with the previous correspondence. It is also helpful when members state their class of membership.

REGISTER OF MEMBERS—CHANGES OF ADDRESS

MEMBERS are reminded that notifications of change of address should be made to the Secretary of The Institution in London. Where a transfer from the area of one local Centre or Sub-Centre to that of another arises as a result of a change of address the transfer is automatically arranged by headquarters, and the member concerned need not notify also the Honorary Secretary of the local Centre or Sub-Centre.

To obviate the possibility of errors in the records members are particularly requested when notifying a change of address to give their full initials, their previous address and their class of membership.

SUBSCRIPTIONS AND NATIONAL SERVICE

UNDER a recommendation approved by the Council the subscription payable by Graduate and Student members during their term of National Service is reduced to 10s. per annum. A member wishing to take advantage of this dispensation should advise the Secretary of The Institution giving the date of his call-up.

STUDENTS' QUARTERLY JOURNAL

THE first article in the September 1959 number of the *Students' Quarterly Journal* by P. Hammond, M.A., is an intriguing dialogue on p.d. versus e.m.f. which explains why Ohm's law is not a simple and obvious statement. Cathodic protection is discussed by W. Matthewman in an article entitled 'Corrosion of buried structures'.

In addition to book reviews and Section news the scholarship awards for 1959 and the Graduate and Student premium awards for 1958 are included. This is a delayed issue of only 28 pages owing to the recent printing dispute.

CONVENTION ON STEREOPHONIC SOUND RECORDING, REPRODUCTION AND BROADCASTING

THE papers and discussions at the convention on stereophonic sound recording, reproduction and broadcasting will be published at the end of November 1959 in Supplement No. 14 to Part B of the *Proceedings*. This supplement—with its contents and index pages and in a semi-stiff cover—will be complete in a single issue. The prices (post-free) are 10s. to members of The Institution and 17s. 6d. to non-members.

Copies may be obtained on application to the Secretary of The Institution.

TURBINIA MEMORIAL

THE Council of the North East Coast Institution of Engineers and Shipbuilders have undertaken to endeavour to raise the necessary funds to carry out reconstruction work on the *Turbinia*, the first ship to be propelled by steam turbine, and to provide part of the cost of suitably housing it in a special annex to the Museum of Science and Engineering, Newcastle upon Tyne. This follows discussions with the Newcastle upon Tyne Corporation and the bringing of the stern portion of the ship to Newcastle from the South Kensington Museum where it was exhibited for many years. The stem and the boiler have long been included in the Newcastle Museum collection.

It will be necessary to raise not less than £15000 and the North East Coast Institution has already received donations or guarantees totalling over £10000. Having in mind the outstanding significance of the *Turbinia* in the history of engineering and also the national character of the memorial to the inventor of the steam turbine, Sir Charles A. Parsons, it is felt that members might wish to have the opportunity of subscribing to the fund.

Any member wishing to subscribe should send his contribution to the North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle upon Tyne 1. Cheques should be made payable to that Institution's *Turbinia* Memorial.

HARWELL REACTOR SCHOOL

THE third Reactor School course on the control and instrumentation of reactors will take place from the 1st to 12th February 1960 at Durley Hall, Bournemouth, Hampshire.

The course which will be open to British and oversea students will deal with these topics: elementary reactor physics; revision of elementary reactor kinetics, control and instrumentation; automatic control of reactors and nuclear power plants; application of computers; reactor transfer functions and function analysers; neutron-counting equipment; neutron-flux detectors; neutron-flux scanning; radiation detectors and their siting in reactors; reactor safety circuits; conventional instrumentation; use of transistors in reactor instrumentation; burst-slug detection; design of control mechanisms; spatial instabilities in reactors; and data-reduction problems in large reactors.

The fee for the course is 50 guineas exclusive of accommodation, and application forms should be returned by the 11th December 1959.

The fourth course on the control and instrumentation of reactors will be held from the 23rd May to 3rd June 1960.

The 20th standard course at the school will begin on the 4th January and continue until the 29th April 1960. The fee for the course which is designed to train engineers in the techniques of reactor construction and operation is £250 exclusive of accommodation. Half the places at each course are allocated to oversea students.

The 10th course for senior technical executives will be held from the 9th to 20th May 1960. The fee is 50 guineas exclusive of accommodation.

Application forms and details of all courses can be obtained from the Principal, Reactor School, Atomic Energy Research Establishment, Harwell, Didcot, Berkshire.

CIVILIAN STUDENTSHIPS

PARTICULARS of civilian studentships at the Royal Military College of Science, Shrivenham, were given in the February 1959 *Journal*, p. 121. Successful candidates join officers in degree courses, normally of three years, which prepare students for the London University degree of B.Sc.(Special)

in chemistry, physics or mathematics or of B.Sc.(Engineering). The courses are specially designed for training young scientists for Government research establishments, and boys to whom awards are made are expected to join the Scientific Civil Service when they have taken their degrees.

Candidates must be under 22 on the 1st October of the year of entry unless they have completed their National Service when they must be under 24. The preliminary qualifying examination will be held in February 1960 for the courses beginning in October 1960.

Application forms and further information may be obtained from the Ministry of Aviation, Est. 3 (R) 3, Room 512, Adelphi, Strand, London W.C.2.

WOMEN'S ENGINEERING SOCIETY

THE programme for the 1959–60 session of the Women's Engineering Society, London Branch, includes lectures on 'Radar and telecommunications research and development' to be given on the 9th December 1959 by Dr. Elizabeth Laverick; 'Health physics and nuclear power' by Mr. B. C. Godbold to be presented on the 13th January 1960; and 'Electronic weighing' by Miss R. Winslade to be delivered on the 18th May 1960.

Meetings begin at 7 p.m. (tea at 6.30 p.m.) at Hope House, 45 Great Peter Street, Westminster, London S.W.1 and those interested are invited to attend. Details of the complete programme can be obtained from the Secretary, Women's Engineering Society, 25 Foubert's Place, London W.1.

ELECTRONIC COMPONENTS CONFERENCE

THE Professional Group on Component Parts, of the Institute of Radio Engineers, is inviting papers for the 1960 Electronic Components Conference to take place in Washington, D.C., from the 10th to 12th May. The meeting will discuss the development, theory, production and reliability of new electronic components of all kinds.

An intending author is asked to send a 150–200-word abstract by the 15th December 1959 to G. B. Devey, Technical Programme Chairman, Sprague Electric Co., North Adams, Massachusetts, U.S.A.

MILITARY ELECTRONICS

THE 4th national convention on military electronics will be held at the Sheraton-Park Hotel, Washington, D.C., from the 27th to 29th June 1960 under the sponsorship of the Professional Group on Military Electronics of the Institute of Radio Engineers.

Papers presenting original work in this field are invited by the group. Suggested topics include, but are not limited to, the following: current problems of space technology, space electronics, ranging and tracking, electronic propulsion, data-handling systems, guidance and control, inertial systems, reconnaissance systems, communication systems, operation analysis, and reliability.

A prospective author is asked to furnish by the 1st February 1960 three copies of a 250-word unclassified abstract of his proposed paper to Dr. Craig M. Crenshaw, Department of Army, Office of the Chief Signal Officer, R and D Division, SIGRD-2, Washington 25, D.C.

Each author must obtain the appropriate military and company clearances for his abstract.

Electronic recorders for trains

ELECTRONIC analysing recorders are to be used by British Railways electrical and signal engineers to check the performance and efficiency of new h.v. a.c. electrification schemes and equipment and associated signalling installations.

The recorders will provide information which will help the engineers to improve the design of equipment for future electrification schemes and to predict requirements for lines to be converted from steam or Diesel to electric traction.

They will be installed in electric trains and locomotives and at points along test sections of electrified line to register such data as the speed and position of trains in relation to changes in voltage and current in varying load conditions. They will be employed first on two recently completed pilot schemes, between Slades Lane Junction and Wilmslow on the Crewe–Manchester main line and between Colchester and Clacton.

In a large-scale recording operation British Railways expect to use up to 24 instruments monitoring a variety of equipment over a wide area. They can be synchronized and operated remotely through a master recorder.

Based on the computer principle the recorders will code and store information on punched tape which will be processed later by standard computers. The computers will automatically print characteristic features in tabular form.

Radioisotope test for insulated wire

A SCIENTIST of the United Kingdom Atomic Energy Authority has devised a method of continuously testing the insulation on a cable by means of radioisotopes.

When manufacturing insulated wire it is not easy to tell whether the strands of conductor metal are in the centre of the insulation or whether there are spots where the insulating skin is thin. Even the use of transparent insulating material cannot solve the problem completely.

In the new device radiation from two isotope sources is split by lead blocks into two slightly divergent pairs of thin beams. These form a frame of radiation in the centre of which is the conducting wire. So long as the wire remains in the middle of the frame while the cable moves through the device, the intensity of the four beams emerging from the cable remains the same since they pass through appreciably equal thicknesses of the same material.

However if there is a thin spot in the covering material, i.e. if the wire core moves to one side, one or two of the beams are affected because the metal absorbs a different amount of radiation.

Detectors of the emergent beams indicate this change in intensity and can be linked so as to show on which side is the thin insulation.

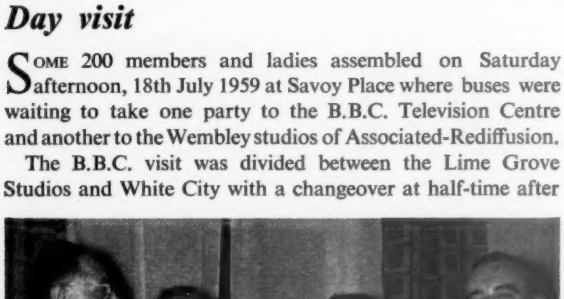
BULLETIN OF THE SECTIONS

ELECTRONICS AND COMMUNICATIONS

Day visit

SOME 200 members and ladies assembled on Saturday afternoon, 18th July 1959 at Savoy Place where buses were waiting to take one party to the B.B.C. Television Centre and another to the Wembley studios of Associated-Rediffusion.

The B.B.C. visit was divided between the Lime Grove Studios and White City with a changeover at half-time after



Mr. A. J. Young (left) and Mr. G. Millington (second from right) in a group at the cocktail party

tea in the canteen of the finished part of the Television Centre when Mr. M. J. L. Pulling, now Chairman of the Section, welcomed the guests on behalf of the B.B.C. staff and Mr. G. Millington, the then Chairman, in expressing the thanks of the Section referred to the co-operation that has always existed between the B.B.C. and The Institution.

Lime Grove

At Lime Grove the visitors saw various 'sets' in process of erection and the final preparations for the Billy Bunter episode scheduled for 5.30 p.m. Particular interest was shown in the camera and microphone arrangements and in the technical intricacies of the control and monitoring rooms.

At the Television Centre the 'props' store was a fascinating sight in its juxtapositions of incongruous articles all carefully indexed, and equally entertaining was the making of scenery with extensive use of glass-fibre moulding and a novel method of painting large canvases rapidly.

The Wembley visitors likewise found the large collection of studio 'props' of interest not only because of its resemblance to a rather exotic second-hand shop, but also because it provided an opportunity to 'guess the programmes' in which some of the more unusual objects had appeared.

They also studied the cameras, the studio lighting and the film-scanning and teleciné equipment. Many were surprised at the amount of apparatus needed for outside broadcasts that had to be squeezed into a vehicle.

No television set

The visit included a look at the new studio being built at Wembley which will considerably add to the resources of Associated-Rediffusion.

At 5.30 p.m. the whole party met again at the Kensington Palace Hotel where they were the guests of the English Electric Valve Company at a cocktail party. This was an enjoyable and informal occasion during which Mr. A. J. Young, the general manager of the company, made a short speech of welcome and Mr. Millington in reply confessed that he had no television set. Afterwards those who had been successful in the ballot for the available tickets went to see Tommy Trinder open his Trinder Box at the B.B.C. Television Theatre.

It was generally agreed that the visit was an intriguing variant on the day outing centred on a lunch which the Section has held for some years past. G. M.

A thumb-nail sketch of the new Chairman

MR. M. J. L. PULLING joined The Institution as a Graduate in 1929, becoming an Associate Member in 1935 and a Member in 1945. He served on the Section Committee from 1950 to 1953 and was a Vice-Chairman of the Section from 1957 to 1959. He was born on the 30th May 1906 and educated at Marlborough and at King's College, Cambridge, obtaining a B.A. degree in mechanical sciences at the age of 22. After completing a year's research in the Wireless Laboratory at Cambridge and a year's apprenticeship with International Telephone and Telegraph Laboratories Inc. he became a research engineer with Wireless Music Ltd. He left two years later to join Murphy Radio.

M. J. L. Pulling, Chairman of the Electronics and Communications Section

It was in 1934 that he began his long association with the B.B.C., in the Engineering Information Department. Four years later he was appointed assistant to the assistant chief engineer, and in 1941 he became superintendent engineer of the Recording Department.

He took charge of the Television Operations and Maintenance Department in 1949 and in 1956 was made controller of Television Service Engineering.

He was appointed an O.B.E. in 1954 and promoted C.B.E. in 1958. He has been a vice-president of the British Sound Recording Association for a number of years.

MEASUREMENT AND CONTROL

New digital-computer techniques

THE specialist discussion meetings on new digital-computer techniques held at Savoy Place on the 16th–17th February 1959 and organized by the Measurement and Control Section represented a new departure in the dissemination of information and were frankly experimental in character. They were designed to give members the most up-to-date possible specialist account of work in progress in a rapidly developing sphere without in any way prejudicing its subsequent more formal presentation.

The meetings concentrated on four main topics which were considered to be of the greatest interest: character recognition, peripheral equipment, low-temperature storage and switching devices, and special aspects of logical design. They were spread over six sessions occupying two full days. In each of the subjects it was arranged for a leading authority to give an introductory lecture followed by several contributions from experts. Such contributions were each designed to occupy about 15 minutes, an equal time being allowed for the ensuing discussion.

Tradition of formality

Inevitably in a new venture of this kind some rough edges became evident as the meetings proceeded. Perhaps they did not altogether achieve their desired freedom from inhibitions because of the long tradition of formality associated with the Lecture Theatre.

Contributors' written summaries exhibited too wide a variation in style and content: some gave a fulsome précis while others briefly indicated the general content. Some succeeded better than others in 'getting it over' in the course of a lecture and in stimulating an animated discussion. Despite all such shortcomings the meetings, which were very fully attended, largely succeeded in attaining their objects. The various experts were brought together and members were regaled with first-hand accounts of the latest developments. One gratifying feature is that the meetings attracted international interest, two contributions coming from Western Germany.

It must be remembered that the meetings were designed for *specialists* which makes it more difficult to apply ordinary criteria of popular appeal. It is important however that some mechanism should be evolved so that workers in certain fields of a quickly advancing science can be apprised without undue delay of what other workers in relative spheres are doing so that they can direct their activities to the best advantage. The difficulty associated with the formal presentation of papers lies of course in the time involved.

Highlights of the sessions

It would be invidious to single out any particular session for special mention; they all had some noteworthy features. The topic of character recognition introduced by Mr. C. E. G. Bailey was of great general interest. The highlight in the subject of peripheral equipment ushered in by Mr. B. W. Pollard was perhaps the xerographic printer in which characters are displayed at the rate of 5000 per second.

Dr. D. R. Young, a visitor from the United States, introduced the session on low-temperature storage and switching devices. His talk and the excellence of the ensuing lectures made this an outstanding session. Dr. M. V. Wilkes in initiating the final sessions on special aspects of logical design achieved a closer intimacy with his audience by using a small blackboard set away from the rostrum. His impromptu lecture demonstrated the spirit in which the meetings might better have been conducted.

Similar meetings are now being organized to take place under the aegis of Group B of the British Conference on Automation and Computation and in co-operation with the British Computer Society on the 20th–21st January 1960 on 'Managerial and engineering aspects of reliability and maintenance of digital-computer systems'. It will be interesting to see how such meetings develop and whether members will come to regard them as permanent features of The Institution's life.

J. K. W.

SUPPLY

Summer visit to Dublin

THE attraction of the Emerald Isle was clearly demonstrated by the response of some 150 members of the Section with their ladies to the invitation of the Irish Branch to base the 1959 summer visit on Dublin. The main party arrived on Thursday, the 10th September and were greeted by Mr. R. L. S. McDowell, Chairman of the Irish Branch.

From the visit headquarters at the Shelbourne Hotel was but a short step to Iveagh House where at the invitation of the Minister for Transport and Power and Mrs. Childers we were received with traditional Irish hospitality.

Rural electrification

On Friday we had the choice of nine visits, all of them well patronized, two being all-day tours. The first was to Ferbane power station with lunch provided by Bord na Mona (Turf Board). The party toured the bog to see the latest mechanized method of working, drying and transporting the milled peat to the adjacent power station with its purpose-designed boilers fired by pulverized dried peat. Sufficient fuel is already being produced to drive three 20 MW turbogenerators, and further extensions are planned.

The second all-day visit, nearly as remote, was to

Supply (continued)

Ballinahown, Athlone, to view the extensive rural-electrification scheme in this sparsely populated area. The construction methods employed utilize most economical designs, and the scheme is carried out on an area basis of approximately 25 square miles.

Arrival at Dublin Airport The Irish Times

Of half-day visits those to Unidare Ltd. and Guinness's Brewery were best supported, and in each case hosts entertained visitors most cordially. A third party were similarly entertained following their tour of the Coras Iompair Eireann workshops at Inchicore Railway Works.

In the afternoon there were four popular visits. For those who had not previously had the pleasure of seeing Dublin's fair city a tour provided the opportunity of doing so. For the water-lover a trip to the Port of Dublin in ideal weather conditions proved refreshing.

Eire has modern film studios near Bray. A coach-load of visitors toured the studios in the third of the afternoon excursions. For many of the ladies an afternoon at an excellent fashion show in Dublin was a natural attraction.

A theatre party was followed by supper at the Shelbourne Hotel. This included Dublin prawns and provided our Chairman, Mr. D. P. Sayers, with the opportunity of thanking our numerous hosts.

Phoenix Park

Saturday morning was carefully left free in our programme—but for mere man? In the afternoon there were alternative excursions, the first being a coach tour of Co. Wicklow. Meanwhile a visit to the Phoenix Park race-meeting was enjoyed by the majority of the visitors. Many profited by the experience.

An early return enabled everyone to enjoy the hospitality of the Chairman and Members of the Electricity Supply Board at a dinner and dance at the Shelbourne Hotel.

On Sunday some made whole-day and morning tours through Co. Wicklow, and some chose the all-day trip to the Boyne Valley, also as the guests of the Irish Tourist Board.

Pilgrimage to Glendalough on Sunday

Thus ended a Supply Section summer visit which abounded in superb Irish hospitality and memorable arrangements by our friends of the Irish Branch. O. W. M.

UTILIZATION

Not yet the avalanche

ACCORDING to the recently published first report of the Electricity Council the total consumption of electricity in England and Wales from all sources of supply was no less than 86200 million kWh during 1958, and it is a sobering thought that the whole of this massive usage of electricity comes within the purview of the Utilization Section in one way or another.

It may be in the field of design and construction on the one hand or the concern of the operating and maintenance engineer on the other, but no matter where the activity lies there is obviously a vast corpus of knowledge and experience which must be of significant interest and value to the members of the Section. One would have thought that there would in consequence be a large and steady flow, if not an avalanche, of papers suitable for reading at meetings of the Section in London and in the Centres. This encourages me to stress again that members who have some useful and up-to-date knowledge to impart should not be diffident about submitting papers for the consideration of the Section.

'All work and no play makes Jack a dull boy' is just as true for members of the Utilization Section as for anyone else, and to show that this aspect of our corporate life is not overlooked I would mention that the Annual Dinner-Dance of the Section will be held on the 15th January 1960 at the Café Royal, Regent Street, London W.1. Application forms are being enclosed to all members of the Section with this issue of the *Journal*. As the date is a Friday, a day which seems best to suit the convenience of most members, it is hoped there will be a good attendance. T. E. HOUGHTON

LONDON REPORT

DISTRICT MEETING AT OXFORD

Education in computation

THE first meeting of the 1959–60 Session was held at the Oxford Office of the Southern Electricity Board on the 7th October 1959. The programme for the new session was introduced by Mr. J. L. Taylor, Convener, followed by the presentation of a paper 'New methods of exploiting electronic computers in the industry' by Mr. H. McGregor Ross, Mr. D. Westwood being in the chair.

Mr. Ross kept his presentation on a basic level making skilful use of block diagrams to explain computer principles. In describing actual operation he took Pegasus as an example, and his oral explanation was supplemented by the use of an excellent colour film which briefly explained typical applications and operation of the machine.

To give practical emphasis to the subject of programme preparation he took the instance of derivation of moments of inertia of rectangular beams, and he neatly rounded off his lecture by handing out duplicated sheets of initial data and final results actually produced by the computer.

After Mr. Ross had answered questions Mr. W. Lee proposed a vote of thanks in which he drew the analogy of the automatic telephone system as a computer. D. W.

News from the Centres

WESTERN CENTRE

Autumn visit of the Supply Group

ON Saturday, 3rd October 1959 the north and south sides of the Supply Group met at Pilning Junction to embus for Avonmouth Docks. There they were met by officials of the Port of Bristol Authority who provided coffee and biscuits before the tour of the docks.

Under the tutelage of three enthusiastic guides the party travelled by coach round the extensive dock area and obtained an excellent introduction to a very large subject.

Members of the Western Centre Supply Group at tea on the lawns of the Ship Hotel, Alveston

Lunch was provided by the P.B.A. at the Hawthorns Hotel. Mr. T. L. Martin, the Engineer-in-Chief, welcomed the guests and Mr. A. G. Milne, Chairman of the Supply Group, expressed their appreciation.

By bus then to Berkeley Castle and wonderful views of the Severn. The Castle has been inhabited continuously for the last 800 years by the same family. A conducted tour told us of a king being murdered and of Cromwell attacking and breaching the wall and showed us a 14th-century kitchen in wonderful condition. Furnishings, tapestries and pictures provided something of interest for everyone.

The arrangements were in the experienced hands of Mr. A. A. Beckingsale to whom we offer our thanks. The good weather, the interesting places, and the efficient organization were pleasantly memorable. D. J. T.

SCOTTISH CENTRE

Inside the circuit-breaker

ACTIVITIES of the 60th session of the Centre founded on the 1st January 1900 as the Glasgow Section began in Edinburgh on the 6th October 1959 when Mr. Rennie the retiring Chairman introduced Mr. J. A. Aked who gave his Chairman's Address on 'Arc-control devices'.

Mr. Aked has been associated with the Grid in Scotland from its inception in 1929 and was therefore very well able to give an account, profusely illustrated and in not-too-technical language, of the various circuit-breaking devices that have been developed since that time; these range from the early explosion pots to the complicated modern air-blast nozzles. No one who heard the lecture can now have any excuse for not knowing what there is inside a circuit-breaker tank.

On the succeeding evening in Glasgow, this being his 'home' Sub-Centre, Mr. Aked was officially inaugurated as Chairman with the usual formalities and again presented his Chairman's Address.

Jubilee

To mark the Jubilee Year the Centre is organizing a conversazione to be held at the Bute Hall of Glasgow University in January 1960, the Edinburgh dinner in March will be a special Jubilee function and, in conjunction with the North-Eastern Centre which was founded at the same time, a pair of signature desks are to be presented to The Institution for use at the entrance to the rebuilt Lecture Theatre at Savoy Place. Furthermore The Institution's Summer Meeting is to be held in Scotland in 1960 so that the session just started may be the most memorable in the Centre's history. E. O. T.

News from abroad

QUEENSLAND OVERSEA COMMITTEE

Computers for engineers

THE annual combined meeting with the Institution of Engineers, Australia, was held in the public lecture hall of the University of Queensland at St. Lucia on the 10th July 1959. This year it was our turn to provide the speaker, and the meeting was under the chairmanship of Mr. A. S. Faulkner. The speaker was J. M. Bennett, B.SC., B.E., PH.D., A.M.I.E.E., senior numerical analyst of the Department of Physics, University of Sydney, whose subject was 'Computers and their applications to engineering problems'.

Dr. Bennett briefly outlined the principles on which computers work, referring to their speed of operation and capacity for storing information. For illustration he likened the automatic computer to a trained person working to a set programme of calculations with the assistance of a simple desk calculating machine and having access to stored knowledge in the form of books of tables and other technical data. The procedure followed in both cases was substantially the same but the automatic computer was 8000–10000 times faster than the human operator.

A further difference was that the human computer could think and vary his attack accordingly whereas the automatic unit must adhere rigidly to the programme presented to it. This emphasized the need for considerable care in preparing the programme for the automatic computer since it will follow its instruction whether correct or incorrect.

The speaker pleaded for an introduction to computer techniques during engineering courses because young engineers would then enter their careers with a knowledge of what computers can do and could thus take advantage of the facilities they provide.

Realization of potentialities

Owing to the volume and complexity of their calculations aircraft designers had been among the first users of computers, but now there was a wider realization of the potentialities. Computers were applied to hydraulic engineering, reinforced-concrete design, telephone-traffic problems, and determining optimum operating conditions in chemical plants. Because of their versatility they were tending to displace analogue devices, particularly as they did not require the addition of 'gadgets' to meet extensions to a particular problem. This versatility is further illustrated by the fact that in the computer laboratory quite simple problems are referred to the machine as well as the most complex. The availability of a library of programmes greatly eases and accelerates the solving of problems.

In moving a vote of thanks Mr. E. C. Morwood reminded the audience which numbered about 100 that Dr. Bennett is a Queenslander by birth who received his earlier training in the engineering faculty of the University of Queensland under Dr. Boyd who had now retired but was present at the lecture. He felt that the widespread interest in computers indicated a growing need for a computer centre in Brisbane. W. I. G.

TRINIDAD AND TOBAGO JOINT GROUP

Navet reservoir

NEARLY 70 members and their guests visited the almost completed Navet reservoir on the 5th September 1959 and spent a most enjoyable and interesting Saturday afternoon. This reservoir will supply pure water to much of the southern part of Trinidad and consists of three major sections, the Navet dam, the treatment plant and pumping station, and a 36in. trunk main.

The dam for impounding the waters of the Navet River is mainly of clay obtained from nearby borrow areas: the water faces are blanketed with rock to prevent erosion, and a road over 1150ft long is being built across the top.

The spillway which forms a major part of the construction works has been designed to pass approximately 140 million g.p.h. This is the overflow that has been predicted as possible once in 100 years and is based on experience of similar catchments in many parts of the world.

Mr. Noel Griffiths discovers an amusing aspect

For the control of the quality of the fill being placed a soils laboratory has been set up on site, and over 1500 samples have been taken from the embankment and tested for density, moisture content and strength as the work has progressed. To prevent any possibility of slipping, numerous cells for measuring the pressure of the water on the underlying alluvium have been installed, and to enable the behaviour of the fill to be checked against design predictions apparatus for the measurement of settlement has been provided.

Mr. Noel Griffiths, A.M.I.C.E., was largely responsible for the visit, and in addition to the inspection of the work in progress there was an exhibition of maps, photographs and diagrams. D. P. J. H.

OFFICERS OF THE INSTITUTION

PATRON: H.M. THE QUEEN

Council, 1959-60

PRESIDENT — SIR WILLIS JACKSON, D.SC., F.R.S.

PAST-PRESIDENTS
W. H. ECCLES, D.SC., F.R.S.
THE RT. HON. THE EARL OF MOUNT EDGCUMBE, T.D.
J. M. DONALDSON, M.C.
PROF. E. W. MARCHANT, D.SC.
H. T. YOUNG
SIR GEORGE LEE, O.B.E., M.C.
SIR ARTHUR P. M. FLEMING, C.B.E., D.ENG., LL.D.
J. R. BEARD, C.B.E., M.SC.
SIR NOEL ASHBRIDGE, B.SC.(ENG.)
SIR HARRY RAILING, D.ENG.
P. DUNSHEATH, C.B.E., M.A., D.SC.(ENG.), LL.D.
SIR VINCENT Z. DE FERRANTI, M.C.
T. G. N. HALDANE, M.A.
PROF. E. B. MOULLIN, M.A., SC.D., LL.D.
SIR ARCHIBALD J. GILL, B.SC.(ENG.)
SIR JOHN HACKING
COL. B. H. LEESON, C.B.E., T.D.
SIR HAROLD BISHOP, C.B.E., B.SC.(ENG.)
SIR JOSIAH ECCLES, C.B.E., D.SC.
SIR GEORGE H. NELSON, BART.
SIR W. GORDON RADLEY, K.C.B., C.B.E., PH.D.(ENG.)
S. E. GOODALL, M.SC.(ENG.), F.Q.M.C.

VICE-PRESIDENTS
O. W. HUMPHREYS, C.B.E., B.SC.
G. S. C. LUCAS, O.B.E., F.C.G.I.
SIR HAMISH D. MACLAREN, K.B.E., C.B., D.F.C., LL.D., B.SC.
C. T. MELLING, C.B.E., M.SC.TECH.
A. H. MUMFORD, O.B.E., B.SC.(ENG.)

HONORARY TREASURER — E. LEETE

Ordinary Members of Council
PROF. H. E. M. BARLOW, PH.D., B.SC.(ENG.)
C. O. BOYSE, B.SC.(ENG.)
PROF. M. W. HUMPHREY DAVIES, M.SC.
SIR JOHN DEAN, B.SC.
L. DRUCQUER
J. M. FERGUSON, B.SC.(ENG.)
D. C. FLACK, B.SC.(ENG.), PH.D.
J. S. FORREST, D.SC., M.A.
R. J. HALSEY, C.M.G., B.SC.(ENG.)
J. B. HIGHAM, PH.D., B.SC.
R. A. HORE, M.A., B.SC.
F. C. McLEAN, C.B.E., B.SC.
B. L. METCALF, B.SC.(ENG.)
J. R. MORTLOCK, PH.D., B.SC.(ENG.)
H. G. NELSON, M.A.
R. H. PHILLIPS, T.D.
H. V. PUGH
J. R. RYLANDS, M.SC., J.P.
G. A. V. SOWTER, PH.D., B.SC.(ENG.)
C. E. STRONG, O.B.E., B.A., B.A.I.
D. H. TOMPSETT, B.SC.(ENG.)

Chairmen and Past-Chairmen of Sections

Electronics and Communications
M. J. L. PULLING, C.B.E., M.A.
*G. MILLINGTON, M.A., B.SC.

Measurement and Control
PROF. A. TUSTIN, M.SC.
*J. K. WEBB, M.SC.(ENG.), B.SC.TECH.

Supply
J. R. MORTLOCK, PH.D., B.SC.(ENG.)
*D. P. SAYERS, B.SC.

Utilization
T. E. HOUGHTON, M.ENG.
*R. A. MARRYAT, B.SC.(ENG.)

Chairmen and Past-Chairmen of Local Centres

East Midland
D. H. PARRY, B.SC.
*D. E. LAMBERT, B.SC.(ENG.)

Mersey and North Wales
T. A. P. COLLEDGE, B.SC.(ENG.)
*J. COLLINS

North-Eastern
H. WATSON-JONES, M.ENG.
*A. T. CRAWFORD, B.SC.

North Midland
PROF. G. W. CARTER, M.A.
*J. D. NICHOLSON, B.SC.

North-Western
F. J. HUTCHINSON, M.ENG.
*PROF. F. C. WILLIAMS, O.B.E., D.SC., D.PHIL., F.R.S.

Northern Ireland
T. S. WYLIE
*D. S. McILHAGGER, PH.D., M.SC.

Scottish
J. A. AKED, M.B.E.
*R. J. RENNIE, B.SC.

South Midland
G. F. PEIRSON
*L. L. TOLLEY, B.SC.(ENG.)

Southern
W. D. MALLINSON, B.SC.(ENG.)
*G. BISHOP, B.SC.

Western
H. JACKSON, B.SC.(ENG.)
*R. W. STEEL

* *Past-Chairman*

SECRETARY	W. K. BRASHER, C.B.E., M.A., M.I.E.E.
Deputy Secretary	F. JERVIS SMITH, M.I.E.E.
Principal Assistant Secretary	F. C. HARRIS
Assistant Secretary	N. C. STAMFORD, M.SC.TECH., M.I.E.E.
Chief Accountant	F. H. JOB, F.A.C.C.A., A.C.I.S.
Editor-in-Chief	G. E. WILLIAMS, B.SC.(ENG.), M.I.E.E.
Editor, *Journal*	W. G. ASKEW, M.C.
Editor, *Science Abstracts*	B. M. CROWTHER, M.A., PH.D.

Headquarters Committees, 1959-60

The President is, *ex officio*, a member of all Committees of The Institution

Council Committees

EDUCATION AND TRAINING

Chairman: G. S. C. Lucas, O.B.E., F.C.G.I.

Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)
Prof. M. W. Humphrey Davies, M.SC.
The Rt. Hon. The Viscount Falmouth
S. E. Goodall, M.SC.(ENG.), F.Q.M.C.
R. J. Halsey, C.M.G., B.SC.(ENG.)
Col. B. H. Leeson, C.B.E., T.D.
F. C. McLean, C.B.E., B.SC.
C. T. Melling, C.B.E., M.SC.TECH.
B. L. Metcalf, B.SC.(ENG.)
J. D. Nicholson, B.SC.
H. V. Pugh
R. J. Rennie, B.SC.
G. A. V. Sowter, PH.D., B.SC.(ENG.)
C. E. Strong, O.B.E., B.A., B.A.I.

EXAMINATIONS

Chairman: A. H. Mumford, O.B.E., B.SC.(ENG.)

Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D.
Prof. M. W. Humphrey Davies, M.SC.
H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.)
J. B. Higham, PH.D., B.SC.
R. A. Hore, M.A., B.SC.
G. Millington, M.A., B.SC.
Prof. M. G. Say, PH.D., M.SC., F.R.S.E.
D. P. Sayers, B.SC.

Ex officio: Chairmen of the Joint Committee for National Certificates for England and Wales, Scotland and Northern Ireland; G. S. C. Lucas, O.B.E., F.C.G.I.; Prof. B. Hague, D.SC., PH.D.; J. R. W. Murland, B.SC.(ENG.)

FINANCE

Chairman: G. S. C. Lucas, O.B.E., F.Q.M.C.

Sir Noel Ashbridge, B.SC.(ENG.)
C. O. Boyse, B.SC.(ENG.)
Sir John Dean, B.SC.
Sir Josiah Eccles, C.B.E., D.SC.
S. E. Goodall, M.SC.(ENG.), F.Q.M.C.
C. T. Melling, C.B.E., M.SC.TECH.
Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.)
L. L. Tolley, B.SC.(ENG.)

Ex officio: E. Leete (Hon. Treasurer); The Chairman of the General Purposes Committee

GENERAL PURPOSES

Chairman: Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC.

Sir Harold Bishop, C.B.E., B.SC.(ENG.)
J. Collins
A. T. Crawford, B.SC.
L. Drucquer
Sir Josiah Eccles, C.B.E., D.SC.
S. E. Goodall, M.SC.(ENG.), F.Q.M.C.
R. J. Halsey, C.M.G., B.SC.(ENG.)
B. L. Metcalf, B.SC.(ENG.)
H. G. Nelson, M.A.
C. E. Strong, O.B.E., B.A., B.A.I.

Ex officio: The Vice-Presidents; E. Leete (Hon. Treasurer)
also the Chairmen of the four Section Committees

LIBRARY AND MUSEUM

Chairman: P. Dunsheath, C.B.E., M.A., D.SC.(ENG.), LL.D.

Sir Noel Ashbridge, B.SC.(ENG.)
J. S. Forrest, D.SC., M.A.
Sir John Hacking
J. B. Higham, PH.D., B.SC.
T. E. Houghton
R. W. Steel
L. L. Tolley, B.SC.(ENG.)

PAPERS

Chairman: O. W. Humphreys, C.B.E., B.SC.

G. Bishop, B.SC.
L. Drucquer
J. M. Ferguson, B.SC.(ENG.)
D. C. Flack, B.SC.(ENG.), PH.D.
J. S. Forrest, D.SC., M.A.
R. A. Hore, M.A., B.SC.
D. H. Tompsett, B.SC.(ENG.)

Ex officio: The Chairmen of local Centres and representatives of the four Section Committees

RESEARCH

Chairman: Sir Willis Jackson, D.SC., F.R.S.

Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)
J. F. Coales, O.B.E., M.A.
Prof. M. W. Humphrey Davies, M.SC.
J. M. Ferguson, B.SC.(ENG.)
D. C. Flack, B.SC.(ENG.), PH.D.
J. S. Forrest, D.SC., M.A.
R. J. Halsey, C.M.G., B.SC.(ENG.)
O. W. Humphreys, B.SC.
J. S. McPetrie, PH.D., D.SC.
Prof. G. H. Rawcliffe, M.A., D.SC.
R. L. Smith-Rose, C.B.E., D.SC., PH.D.
D. Taylor, M.SC., PH.D.
D. H. Tompsett, B.SC.(ENG.)

Specialized Section Committees

MEASUREMENT AND CONTROL SECTION

Chairman: Prof. A. Tustin, M.SC.

Vice-Chairmen: W. S. Elliott, M.A.; C. G. Garton

Past-Chairmen: J. K. Webb, M.SC.(ENG.), B.SC.TECH.; H. S. Petch, B.SC.(ENG.)

E. W. Connon, B.SC.(ENG.), M.ENG.
A. C. Lynch, M.A., B.SC.
A. J. Maddock, D.SC.
R. E. Martin
A. Nemet, DR.SC.TECHN.
S. N. Pocock
W. Renwick, M.A., B.SC.
G. A. V. Sowter, PH.D., B.SC.(ENG.
G. F. Tagg, PH.D., B.SC.
R. D. Trotter, B.SC.(ENG.)
J. H. Westcott, B.SC.(ENG.), PH.D.
F. C. Widdis, B.SC.(ENG.)

together with the following:

Chairman, Papers Committee
G. A. V. Sowter, PH.D., B.SC.(ENG.) (representing the Council)
C. C. Baxendale (representing the North-Eastern Measurement and Electronics Group)
H. M. Gale, B.SC.(ENG.) (representing the South Midland Electronics and Measurement Group)
E. J. R. Hardy, B.SC.(ENG.) (representing the North-Western Measurement and Control Group)
D. L. A. Barber, B.SC.(ENG.) (nominated by the National Physical Laboratory)

ELECTRONICS AND COMMUNICATIONS SECTION

Chairman: M. J. L. Pulling, C.B.E., M.A.

Vice-Chairmen: R. J. Halsey, C.M.G., B.SC.(ENG.); J. A. Ratcliffe, C.B.E., M.A., F.R.S.; T. B. D. Terroni, B.SC.

Past-Chairmen: G. Millington, M.A., B.SC.; J. S. McPetrie, PH.D., D.SC.

D. A. Barron, M.SC.
P. A. T. Bevan, C.B.E., B.SC.
J. Brown, M.A., PH.D.
Prof. A. L. Cullen, PH.D., B.SC.(ENG.)
L. I. Farren, M.B.E.
G. G. Gouriet
C. G. Mayer, O.B.E.
J. Moir
L. J. I. Nickels, B.SC.(ENG.)
B. G. Pressey, M.SC.(ENG.), PH.D.
N. C. Rolfe, B.SC.(ENG.)
T. R. Scott, D.F.C., B.SC.
C. Williams, B.SC.(ENG.)
W. E. Willshaw, M.B.E., M.SC.TECH.
R. C. Winton, B.SC.
A. J. Young, B.SC.(ENG.)

together with the following:

Chairman, Papers Committee
Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.) (representing the Council)
E. H. Cooke-Yarborough, M.A. (co-opted member)
G. H. Hickling, B.SC. (representing the North-Eastern Measurement and Electronics Group)
K. F. Sander, M.A., PH.D., B.SC. (representing the Cambridge Electronics and Communications Group)
R. E. Young, B.SC.(FNG.) (representing the South Midland Electronics and Measurement Group)
R. Feinberg, DR.-ING., M.SC. (representing the North-Western Electronics and Communications Group)
Capt. W. D. F. B. Muspratt, R.N. (nominated by the Royal Navy)
Col. R. G. Miller, M.A. (nominated by the Army)
Goup-Capt. D. W. Rowson, B.SC.(ENG.), R.A.F. (nominated by the Royal Air Force)

SUPPLY SECTION

Chairman: J. R. Mortlock, PH.D., B.SC.(ENG.)

Vice-Chairmen: J. S. Forrest, D.SC., M.A.; D. B. Irving, B.SC.; J. E. L. Robinson, M.SC.

Past-Chairmen: D. P. Sayers, B.SC.; Prof. M. G. Say, PH.D., M.SC., F.R.S.E.

G. S. Buckingham, B.SC.(ENG.)
W. J. Carfrae, B.SC.
J. L. Egginton, B.SC.
C. H. Flurscheim, B.A.
C. J. O. Garrard, M.SC.
W. D. Horsley
D. McDonald, B.SC.
O. W. Minshull, B.SC.
W. J. Nicholls, B.SC.
J. E. Peters, B.SC.TECH.
T. W. Wilcox
A. L. Williams, PH.D., M.SC.

together with the following:

Chairman, Papers Committee
H. V. Pugh (representing the Council)
A. C. Ehrenberg (representing the North-Western Supply Group)
E. V. Hardaker, M.C., B.SC. (representing the South Midland Supply and Utilization Group)
N. Care (representing the Western Supply Group)

UTILIZATION SECTION

Chairman: T. E. Houghton, M.ENG.
Vice-Chairmen: J. M. Ferguson, B.SC.(ENG.); H. G. Taylor, D.SC.(ENG.)
Past-Chairmen: R. A. Marryat, B.SC.(ENG.); J. Vaughan Harries

J. R. Anderson, T.D., B.SC.(ENG.)
S. L. M. Barlow
J. W. Binns
J. A. Broughall, B.SC.(ENG.)
C. M. Cock
O. T. Evans
W. J. Gibbs, D.SC.
R. J. Harding, T.D.
R. P. McCulloch, B.ENG.
R. F. Richardson, M.B.E.
W. G. Thompson, PH.D., B.SC.
J. Tozer
C. D. Wilkinson

together with the following:
Chairman, Papers Committee
B. L. Metcalf, B.SC.(ENG.) (representing the Council)
P. Smith, B.SC. (representing the Western Utilization Group)
W. E. G. Robinson, B.SC.(ENG.) (representing the North-Western Utilization Group)
S. F. Adcock (representing the South Midland Supply and Utilization Group)
G. Auton (representing the North Midland Utilization Group)
S. J. Emerson, M.ENG. (nominated by the Ministry of Labour and National Service, Factory Department)
P. Smith, B.SC. (nominated by the Admiralty)
P. McKearney, O.B.E. (nominated by the Ministry of Works)
H. F. Innocent (nominated by the Air Ministry)
C. L. Champion, B.SC. (nominated by the War Office)

INFORMAL MEETINGS COMMITTEE

Chairman: F. J. Lane, O.B.E., M.SC.

D. A. Barron, M.SC.
J. A. Broughall, B.SC.(ENG.)
E. H. Jesty
W. C. Lister, B.SC.
G. Millington, M.A., B.SC.
K. C. Pounds, B.SC.(ENG.)
T. B. Rolls, B.A.
W. Ross, M.A.
Prof. A. Tustin, M.SC.
F. C. Walmsley
R. C. G. Williams, PH.D., B.SC.(ENG.)

together with the following:
Chairman, Papers Committee
L. Drucquer (representing the General Purposes Committee)
Chairman of the London Graduate and Student Section

LONDON GRADUATE AND STUDENT SECTION

(operating directly under the Council)
Chairman: L. A. Harris, B.SC.(ENG.)
Vice-Chairman: P. M. Norris
Hon. Secretary: F. P. Harwood, 179 Sutherland Avenue, London W.9
Council's Representative: G. Millington, M.A., B.SC.

Special Committees

LOCAL CENTRES

J. Collins
J. M. Ferguson, B.SC.(ENG.)
D. S. McIlhagger, PH.D., M.SC.
R. H. Philips, T.D.
M. J. L. Pulling, C.B.E., M.A.
H. T. Young

Ex officio: The Vice-Presidents; The Chairmen of local Centres and Sub-Centres

SCHOLARSHIPS

Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)
Prof. M. W. Humphrey Davies, M.SC.
E. M. Hickin
J. B. Higham, PH.D., B.SC.
Prof. M. G. Say, PH.D., M.SC.
R. L. Smith-Rose, C.B.E., D.SC., PH.D.
W. G. Thompson, PH.D., B.SC.
Prof. A. Tustin, M.SC.
H. West, M.SC.

Ex officio: Chairman, Research Committee, or his deputy

OVERSEA ACTIVITIES

S. L. M. Barlow
C. O. Boyse, B.SC.(ENG.)
B. Donkin, B.A.
J. F. Herbert, B.E.
Sir George H. Nelson, BART.
Sir Gordon Radley, K.C.B., C.B.E., PH.D.(ENG.)
D. P. Sayers, B.SC.
D. H. Tompsett, B.SC.(ENG.)

together with the following:
Chairman and Past-Chairman of the Irish Branch
D. Lusk, C.B.E., B.SC. (representing the Ceylon Branch)
F. H. Sharpe, B.SC. (representing the Calcutta Branch)

Representing members in the area shown against their names:

J. R. Beard, C.B.E., M.SC. (*South Africa*)
C. M. Cock (*Australia*)
C. H. de Nordwall (*South America*)
E. H. R. Green, C.B.E., M.SC. (*New Zealand*)
E. A. Logan, M.SC. (*Burma*)
D. H. Mackay, B.SC. (*Crown Colonies*)
R. R. Pattinson (*Pakistan*)
E. J. Prichard, O.B.E. (*Middle East*)
F. H. Sharpe, B.SC. (*India*)
P. J. Tyrrell, B.SC.(ENG.) (*Far East*)

Ex officio: The Vice-Presidents

GRADUATE AND STUDENT SECTION ACTIVITIES

(*Constitution under revision*)

COMMITTEE OF MANAGEMENT, 'SCIENCE ABSTRACTS'

	nominated by
L. G. Brazier, PH.D., B.SC.	Institution of Electrical Engineers
J. A. Broughall, B.SC.(ENG.)	Institution of Electrical Engineers
L. Hartshorn, D.SC.	Institution of Electrical Engineers
R. L. Smith-Rose, C.B.E., D.SC., PH.D.	Institution of Electrical Engineers
J. H. Awberry, M.A., B.SC.	Physical Society
W. R. S. Garton, B.SC.	Physical Society
D. Roaf, M.A., D.PHIL.	Physical Society
Miss A. C. Stickland, M.SC., PH.D.	Physical Society
Prof. W. C. Price, SC.D., F.R.S.	Royal Society
H. W. C. Gatehouse	Central Electricity Generating Board
L. R. G. Treloar, B.SC., PH.D., D.SC.	Institute of Physics

R. T. Webber, B.A., M.S., PH.D. (Observer for the American Physical Society)

ENGINEERING INSTITUTIONS EXAMINATION PART 1

	representing
J. K. T. L. Nash, M.A., M.A.I.	Institution of Civil Engineers
J. L. Paisley, M.B.E., M.ENG.	Institution of Civil Engineers
P. E. Sleight, O.B.E., M.ENG.	Institution of Civil Engineers
Prof. D. G. Christopherson, O.B.E., M.SC., PH.D.	Institution of Mechanical Engineers
Prof. J. L. M. Morrison, D.SC	Institution of Mechanical Engineers
C. W. Tonkin, B.SC.(ENG.)	Institution of Mechanical Engineers
Prof. E. Bradshaw, M.B.E., M.SC.TECH., PH.D.	Institution of Electrical Engineers
H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.)	Institution of Electrical Engineers
A. H. Mumford, O.B.E., B.SC.(ENG.)	Institution of Electrical Engineers
C. H. Taylor-Cook, B.SC.(ENG.)	Institute of Marine Engineers
F. C. Sage	Institution of Municipal Engineers
G. Dougill, M.SC.	Institution of Gas Engineers
R. F. Marryat	New Zealand Institution of Engineers in London
J. France	Institution of Production Engineers

JOINT COMMITTEE ON PRACTICAL TRAINING IN THE ELECTRICAL ENGINEERING INDUSTRY

Chairman: Sir Willis Jackson, D.SC., F.R.S.

F. B. Allcock, B.SC.TECH.
Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)
R. G. Bellamy, O.B.E., T.D., M.ENG.
F. T. Chapman, C.B.E., D.SC.(ENG.)
G. N. Green
H. R. Harbottle, O.B.E., B.SC.(ENG.)
H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.)
F. W. Lawton
F. R. Livock, T.D., B.SC.(ENG.)
R. B. Mackay
R. F. Marshall, B.SC.(ENG.)
B. L. Metcalf, B.SC.(ENG.)
J. F. Richardson, PH.D., B.ENG.
J. D. Stephenson, M.SC., PH.D

and	*representing*
G. S. Bosworth, M.A.	British Electrical and Allied Manufacturers' Association
S. Austen Stigant	British Electrical and Allied Manufacturers' Association
W. H. Taylor, B.SC.(ENG.)	British Electrical and Allied Manufacturers' Association
J. Donegan, B.SC.(ENG.)	Radio Industry Council and Electronic Engineering Association
C. Grad	Radio Industry Council and Electronic Engineering Association
Sir Raymund Hart, K.B.E., C.B., M.C.	Radio Industry Council and Electronic Engineering Association
Prof. H. F. Trewman, M.A.	Radio Industry Council and Electronic Engineering Association

Special Technical Committees

Government appointments as at the 1st October 1959

REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF AIRCRAFT

Chairman: S. E. Goodall, M.SC.(ENG.), F.Q.M.C.

D. C. Flack, B.SC.(ENG.), PH.D.
C. S. Hudson, PH.D., B.SC.
R. H. Woodall
T. G. N. Haldane, M.A.
representing the Utilization Section

and

nominated by
E. Lloyd, B.SC.(ENG.) — Air Registration Board
F. E. Buckell — British Electrical and Allied Manufacturers' Association
V. A. Higgs, B.SC. — British Electrical and Allied Manufacturers' Association
S. E. Whitehead — British Standards Institution
D. W. Bird, B.SC. — Cable Makers Association
F. G. Jales — Ministry of Supply
J. F. Lewis, B.SC.(ENG.) — Ministry of Supply

C. G. A. Woodford	Royal Aeronautical Society
J. Rice	Society of British Aircraft Constructors
Chairman, Electrical Installations Panel	

RADIO EQUIPMENT FOR CIVIL AIRCRAFT COMMITTEE

Chairman: Sir Archibald J. Gill, B.SC.(ENG.)

K. A. F. Frost, B.SC.(ENG.)
Chairman of the Electronics and Communications Section (*ex officio*)

and	*nominated by*
P. F. Cook, B.SC.	Air Registration Board
K. W. B. Fouweather	
D. O'Hanlon	British European Airways Corporation
M. Newman	British Independent Air Transport Association
W. E. Brunt	British Overseas Airways Corporation
C. L. Hirshman	British Radio Valve Manufacturers' Association
D. A. Weale	British Standards Institution
F. G. Jales	Ministry of Supply
G. W. North	Ministry of Transport and Civil Aviation
N. Bordeaux	Post Office
D. A. Beresford	Electronic Engineering Association
H. Holmes	
Appointment pending	Royal Aeronautical Society
D. S. Cooke	Society of British Aircraft Constructors

REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS

Chairman: Forbes Jackson

Vice-Chairman: S. E. Goodall, M.SC.(ENG.), F.Q.M.C.

S. L. M. Barlow	R. A. Marryat, B.SC.(ENG.)
J. I. Bernard, B.SC.TECH.	A. F. Plummer, M.C.
Bryan Donkin, B.A.	H. W. Swann, O.B.E.
H. W. Grimmitt, C.B.E.	G. O. Watson
F. H. Mann	Chairman of the Utilization Section (*ex officio*)
J. S. McCulloch	

and	*nominated by*
C. J. Manning	Admiralty
H. F. Innocent	Air Ministry
W. McDermott, B.SC.	Associated Offices Technical Committee
R. W. H. Couzens, M.A.	Association of Consulting Engineers
W. F. Parker	Association of Supervising Electrical Engineers
E. E. Hutchings, B.SC.(ENG.)	British Electrical and Allied Industries Research Association
T. M. H. Stubbs	British Electrical and Allied Manufacturers' Association
A. J. L. Whittenham	
E. G. Goodhew	British Radio Equipment Manufacturers' Association
J. F. Stanley, B.SC.(ENG.)	British Standards Institution
J. A. Broughall, B.SC.	British Transport Commission
J. R. Cox	Cable Makers Association
H. G. F. Gamble	Central Electricity Generating Board and Area Boards
M. D. Stonehouse	
A. E. J. Whitcher, B.SC.(ENG.)	
W. J. Jones, M.SC.(ENG.)	Electric Lamp Industry Council
C. King	Electrical Contractors' Association
H. G. MacKerron, B.SC.	Electrical Contractors' Association of Scotland
W. S. Gardner	Electricity Board for Northern Ireland
J. K. Hadley	Engineer Surveyors' Association
T. A. Frazer, M.A.	Engineering Equipment Users Association
†C. E. Mills	Fire Offices Committee
G. A. Oliver	Independent Cable Makers' Association
S. J. Emerson, M.ENG.	Ministry of Labour and National Service
A. H. F. Linton	Ministry of Power
J. N. Kass	Ministry of Supply
C. E. Bedford, B.SC.(ENG.)	Ministry of Works
P. N. Wyke, B.SC.	National Coal Board
E. J. Sutton	National Inspection Council for Electrical Installation Contracting
J. C. N. Baillie	North of Scotland Hydro-Electric Board
A. A. Allan	South of Scotland Electricity Board
A. A. C. Walker	War Office

† Alternate: W. R. Whittington

REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF SHIPS

Chairman: G. O. Watson

Sir Archibald J. Gill, B.SC.(ENG.)	A. N. Savage
H. Camden MacEwan	G. J. Tuke, B.SC.
W. C. Robertson, B.SC.	

and	*nominated by*
P. Smith, B.SC.	Admiralty
E. E. Hutchings, B.SC.(ENG.)	British Electrical and Allied Industries Research Association
H. R. Canning	British Electrical and Allied Manufacturers' Association
J. O. Knowles, M.A.	
P. W. Cave, B.SC.	Cable Makers Association
G. J. Tuke, B.SC.	Chamber of Shipping of the United Kingdom
E. F. Sully	
A. V. Milton	Electrical Contractors' Association
W. Muir Goodfellow	Electrical Contractors' Association of Scotland
A. N. Savage	Institute of Marine Engineers
H. B. Hughes, B.SC.(ENG.)	Institution of Engineers and Shipbuilders in Scotland
H. R. Canning	Institution of Naval Architects
J. B. Peacock, B.SC.(ENG.)	Liverpool Steamship Owners' Association
A. G. Stonebanks	
D. Gray, B.SC.	Lloyd's Register of Shipping
S. J. Emerson, M.ENG.	Ministry of Labour and National Service
G. Burdon, B.SC.	Ministry of Transport and Civil Aviation
A. S. Brown, M.B.E.	North East Coast Institution of Engineers and Shipbuilders
Lt.-Col. R. M. Billington, T.D., M.SC.(ENG.)	Post Office
G. J. McDonald, B.SC.(ENG.)	Electronic Engineering Association
J. Blackie	Shipbuilding Conference
Further appointment pending	
F. H. Fletcher, B.ENG.	Telecommunication Engineering and Manufacturing Association

RADIO INTERFERENCE

Chairman: O. W. Humphreys, C.B.E., B.SC.

J. R. Beard, C.B.E., M.SC.	Chairman of the Electronics and Communications Section (*ex officio*)
N. R. Bligh, B.SC.(ENG.)	
F. T. Chapman, C.B.E., D.SC.(ENG.), B.SC.	

and	*nominated by*
Lt. J. N. Wishart, R.N.	Admiralty
‡C. F. Sutton, M.A.	Air Ministry
R. T. B. Wynn, C.B.E., M.A.	British Broadcasting Corporation
A. H. Bennett	British Electrical and Allied Industries Research Association
T. M. H. Stubbs	British Electrical and Allied Manufacturers' Association
Dr. P. Bauwens, M.R.C.S., M.R.C.P.	British Medical Association
D. A. Weale	British Standards Institution
G. O. Watson	B.S.I. Sub-Committee ELE/32/6—Marine Installations
J. S. Forrest, D.SC., M.A.	Central Electricity Generating Board and Area Boards
C. E. Hollingworth, B.ENG.	
R. L. Smith-Rose, C.B.E., D.SC., PH.D.	Department of Scientific and Industrial Research
Appointment pending	Electrical Association for Women
C. J. Veness	Electrical Contractors' Association
J. Stuart Denholm	Electrical Contractors' Association of Scotland
A. H. Cooper, B.SC.	Electronic Engineering Association
P. A. T. Bevan, C.B.E., B.SC.	Independent Television Authority
H. C. Johnson, O.B.E.	Institute of Transport
A. T. Baldock	Ministry of Power
J. T. Penwarden	Ministry of Transport and Civil Aviation
Appointment pending	North of Scotland Hydro-Electric Board
W. J. Bray, M.SC.(ENG.)	Post Office
E. M. Lee, B.SC.	Radio Industry Council
A. H. Ball	Society of Motor Manufacturers and Traders
C. L. Walters	South of Scotland Electricity Board

Technical Secretariat:
E. L. E. Pawley, O.B.E., M.SC.(ENG.)—British Broadcasting Corporation
C. W. Sowton, B.SC.—Post Office
Secretary of The Institution (or his deputy)

‡ Alternate: C. W. Palmer

COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT (ELECTRICAL)

Chairman: T. G. N. Haldane, M.A.

R. W. Mountain, B.SC.(ENG.) J. F. St.G. Shaw, B.SC.(ENG.)

and	*nominated by*
F. H. Dickinson, M.ENG.	Association of Consulting Engineers
K. F. A. Johnston, B.A.	British Electrical and Allied Manufacturers' Association
J. F. B. Barry	
M. Landers	
J. A. Broughall, B.SC.	British Transport Commission
T. S. Pick, B.SC.(ENG.)	
W. A. Bennett	Cable Makers Association
E. J. Gibbons	
L. F. Miller	Electricity supply industry in England and Wales
H. B. Morton	
F. S. Naylor, B.SC.(ENG.)	
L. H. Welch, O.B.E., B.SC.(ENG.)	

L. T. Hinton, B.SC.(ENG.)	Electronic Engineering Association
*M. H. Bower	National Coal Board
G. T. N. Hagart	North of Scotland Hydro-Electric Board
F. W. Oakley	Telecommunication Engineering and Manufacturing Association

with Eric Davies, B.A., LL.B.

* Alternate: W. G. L. Bray

JOINT COMMITTEE ON MODEL FORMS OF GENERAL CONDITIONS OF CONTRACT

(Convened jointly with the Council of The Institution of Mechanical Engineers)

Chairman: T. G. N. Haldane, M.A.

The Presidents of The Institution of Mechanical Engineers and The Institution of Electrical Engineers (*ex officio*)

T. A. Crowe, M.SC.	R. W. Mountain, B.SC.(ENG.)
Norman Elce, M.SC.	J. F. St.G. Shaw, B.SC.(ENG.)
A. C. Hartley, C.B.E., B.SC.(ENG.)	
and	*nominated by*
F. H. Dickinson, M.ENG.	Association of Consulting Engineers
F. J. B. Barry, K. F. A. Johnston, B.A., M. Landers	British Electrical and Allied Manufacturers' Association
A. W. Berry, Keith Fraser, M.A.	British Engineers' Association
L. C. C. Bell	British Iron and Steel Federation
J. A. Broughall, B.SC., E. R. Radway	British Transport Commission
W. A. Bennett, E. J. Gibbons	Cable Makers Association
L. F. Miller, H. B. Morton, F. S. Naylor, B.SC.(ENG.)	Electricity supply industry in England and Wales (Central Electricity Generating Board)
L. H. Welch, O.B.E., B.SC.(ENG.)	Electricity supply industry in England and Wales (London Electricity Board)
L. T. Hinton, B.SC.(ENG.)	Electronic Engineering Association
§M. H. Bower, M.A., LL.B.	National Coal Board
G. T. N. Hagart	North of Scotland Hydro-Electric Board
G. D. G. Perkins, M.A.	Port of London Authority
F. W. Oakley	Telecommunication Engineering and Manufacturing Association
J. B. Laurie	United Kingdom Atomic Energy Authority
C. G. Walkden	Water-Tube Boilermakers' Association

with Eric Davies, B.A., LL.B.

§ Alternate: W. G. L. Bray

OPERATING THEATRES ELECTRICAL APPARATUS COMMITTEE

Chairman: H. T. Young

Forbes Jackson	H. W. Swann, O.B.E.
E. H. Rayner, M.A., SC.D.	Prof. D. T. A. Townend, D.SC., PH.D.
and	*nominated by*
Dr. H. J. V. Morton	British Medical Association
P. G. Phelps, E. H. Willis	Manufacturers of electro-medical apparatus
P. McKearney, O.B.E.	Ministry of Works
Sir Henry S. Souttar, C.B.E.	Royal College of Surgeons
Dr. C. F. Hadfield, M.B.E., M.A.	Royal Society of Medicine
Appointment pending	Wiring Regulations Committee

COURT OF GOVERNORS, INCORPORATED BENEVOLENT FUND

Chairman: The President

Representing the Council:	*Representing the Contributors:*
Prof. H. E. M. Barlow, PH.D., B.SC.(ENG.)	G. D. Arden
J. R. Beard, C.B.E., M.SC.	Capt. C. F. Booth, C.B.E.
Col. B. H. Leeson, C.B.E., T.D.	W. E. Swale
E. Leete	
B. L. Metcalf, B.SC.(ENG.)	
H. V. Pugh	

also the Chairmen of local Centres

Hon. Secretary: W. K. Brasher, C.B.E., M.A.

Local Centre Committees, 1959-60

EAST MIDLAND CENTRE

Chairman: D. H. Parry, B.SC.

Past-Chairmen: Maj. H. E. Knight, E.R.D.; H. L. Haslegrave, M.A., PH.D., M.SC.(ENG.); L. D. Pierce; D. E. Lambert, B.SC.(ENG.)

Vice-Chairmen: Lt.-Col. W. E. Gill, T.D.; N. F. Marsh, M.A.

L. Adlington	H. W. Oldham, M.A.
W. Alexander, M.SC.(ENG.), PH.D.	E. Overstall
F. J. Broadley	Prof. E. Parton, B.SC., PH.D.
R. A. Elsden, B.SC.(ENG.)	E. H. Pooley
A. H. Emerson	R. H. Price
D. R. Hardy, PH.D., M.SC.(ENG.)	H. Topley
Maj. O. W. Nutt, M.B.E., B.SC.(ENG.)	

Ex officio: H. V. Pugh; D. H. McCracken, B.SC.TECH.; Capt. N. Hiller, B.SC.(ENG.)

Hon. Secretary: H. T. Price, D.L.C., Brush Electrical Engineering Co. Ltd., Loughborough

Hon. Asst. Secretaries: I. Barnes, D.L.C., 13 Oakwell Drive, Ilkeston, Derbyshire; W. L. Passant, Switchgear Specialist Engineer, Brush Electrical Engineering Co. Ltd., Loughborough

Hon. Treasurer: H. Buckingham, PH.D., M.SC.(ENG.), Head of Dept. of Electrical Engineering, College of Technology, Loughborough

EAST ANGLIAN SUB-CENTRE

Chairman: D. H. McCracken, B.SC.TECH.

Past-Chairmen: G. E. Middleton, M.A.; R. A. W. Connor

Vice-Chairmen: G. M. Holland; E. A. Fowler

P. E. K. Donaldson, M.A.	W. G. Myall
R. Fyfe	N. C. Rolfe, B.SC.(ENG.)
A. D. J. Goodchild	K. K. Schwarz, M.A.
C. C. Hill, B.SC.(ENG.)	J. H. H. Teece, B.SC.(ENG.)
D. C. Mason	E. Yeeles

Ex officio: Prof. E. B. Moullin, M.A., SC.D., LL.D.; K. F. Sander, M.A., PH.D., B.SC.

Hon. Secretary: Capt. N. Hiller, B.SC.(ENG.), Cambridgeshire Technical College and School of Art, Collier Road, Cambridge

Hon. Asst. Secretary: J. H. Howard, 28a Cavendish Avenue, Cambridge

Hon. Treasurer: F. M. Pratt, B. X. Plastics, Ltd., Brantham Works, nr. Manningtree, Essex

CAMBRIDGE ELECTRONICS AND COMMUNICATIONS GROUP

Chairman: K. F. Sander, M.A., PH.D., B.SC.

Past-Chairman: N. C. Rolfe, B.SC.(ENG.)

Vice-Chairman: H. V. Beck, M.A., B.SC.

D. Allanson	H. A. McGhee
A. H. W. Beck, M.A., B.SC.(ENG.)	T. A. Mugford
S. R. R. Kharbanda	N. W. Weedon

Hon. Secretary: R. Barrass, 2 Acton Way, Cambridge

East Midland Graduate and Student Section

Chairman: A. Wren, D.F.H.

Vice-Chairman: B. Wilson, B.SC.(ENG.), PH.D.

Hon. Secretary: D. G. Walters, B.SC.(ENG.), The Grange, Thorpe Acre, Loughborough

MERSEY AND NORTH WALES CENTRE

Chairman: T. A. P. Colledge, B.SC.(ENG.)

Past-Chairmen: Prof. J. M. Meek, D.ENG.; P. d'E. Stowell, B.SC.(ENG.); T. Makin; J. Collins

Vice-Chairmen: D. A. Picken; R. N. Pegg

J. M. Cowan, DR.ING., B.SC.	D. M. MacLaren
E. G. Forrest	J. A. Mason, C.B.E.
R. D. Haigh, M.ENG.	A. V. Milton
G. R. Harding, T.D., B.A.	T. R. Rayner
K. Helliwell	D. G. Robinson
A. R. Kinsman, B.SC.	A. G. Stonebanks
J. B. Lancaster, B.SC.	A. C. Warman

Ex officio: Prof. E. W. Marchant, D.SC.; J. B. Higham, PH.D., B.SC.

Hon. Secretary: S. Towill, B.SC.(ENG.), Electricity House, Newgate Street, Chester

Hon. Asst. Secretaries: D. Boyd, c/o English Electric Co. Ltd., Liverpool Works, East Lancashire Road, Liverpool 10; J. N. Fletcher, B.SC., PH.D., Brookhirst Switchgear Ltd., Northgate Works, Chester

Hon. Treasurer: W. Parry, M.ENG., 'Scaur', Birkenhead Road, Gt. Meols, Hoylake, Wirral, Cheshire

Mersey and North Wales Graduate and Student Section

Chairman: E. G. Forrest

Vice-Chairman: D. H. Crapper

Hon. Secretary: D. G. Robinson, c/o Electrical Dept., Alfred Holt and Co., India Buildings, Liverpool

NORTH-EASTERN CENTRE

Chairman: H. Watson-Jones, M.ENG.

Past-Chairmen: T. W. Wilcox; A. T. Crawford, B.SC.

Vice-Chairmen: D. H. Thomas, M.SC.TECH., B.SC.(ENG.); P. Richardson

D. F. Amer
C. H. Baker
W. H. Colby
J. H. Dance
F. S. Fay, M.A.
R. W. Fenn, M.ENG.
G. N. Green
E. J. Grubb, B.SC.
G. H. Hickling, B.SC.
R. A. Hore, B.SC., M.A.
C. S. Lawson
G. Lyon, M.SC.(ENG.)
E. J. M. Marrian, B.SC.
F. C. Pratt, B.SC.
R. G. Scotson

Ex officio: C. C. Baxendale; D. W. Pattenden; M. A. Raisbeck
Hon. Secretary: R. Bruce, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6
Hon. Asst. Secretary: R. W. Shield, 152 Edge Hill, Darras Hall, Ponteland, Newcastle upon Tyne
Hon. Treasurer: J. S. McCulloch, Tynedale House, Tynedale Terrace, Hexham, Northumberland

TEES-SIDE SUB-CENTRE

Chairman: M. A. Raisbeck
Past-Chairmen: F. W. Allan; D. G. Furneaux, B.SC.(ENG.)
Vice-Chairmen: J. A. Tatchell, B.SC.(ENG.); T. W. J. Temple
N. Burley
Maj. G. F. Elliott, B.SC., R.E.M.E.
A. E. Evans
W. K. Harrison, B.SC.
R. Headey
R. E. Kenderdine, B.SC.
D. Kirk, B.ENG.
V. F. Lord, B.SC.(ENG.)
E. Markwell
K. S. Millington
J. H. S. Morris, B.SC.
R. J. Patrick
W. Rewcastle, B.SC.

Hon. Secretary: D. W. Pattenden, 45 Stanhope Grove, Acklam, Middlesbrough, Yorks
Hon. Asst. Secretary: N. Miller, B.SC., 104 Houghton Road, Hetton-le-Hole, Co. Durham
Hon. Treasurer: T. S. Seaward, 'Lynnfield', Station Road, Norton, Stockton on Tees

NORTH-EASTERN MEASUREMENT AND ELECTRONICS GROUP

Chairman: C. C. Baxendale; *Past-Chairman:* G. H. Hickling, B.SC.
Vice-Chairman: E. D. Taylor, M.SC.
A. O. Carter, M.ENG.
A. J. Colgan
J. S. Edmondson
A. Gray, B.SC.
H. M. S. Smith
D. H. Thomas, M.SC.TECH., B.SC.(ENG.)

Hon. Secretary: R. Bruce, M.SC., C. A. Parsons and Co. Ltd., Heaton Works, Newcastle upon Tyne 6
Hon. Asst. Secretary: W. B. Dotchin, B.SC., Rutherford College of Technology, Northumberland Road, Newcastle upon Tyne 1
Hon. Treasurer: J. S. McCulloch

North-Eastern Graduate and Student Section

Chairman: W. D. Coutts; *Vice-Chairman:* A. C. Hall
Hon. Secretary and Treasurer: R. Hawley, B.SC., c/o Electrical Engineering Dept., King's College, Newcastle upon Tyne 1

Tees-Side Graduate and Student Section

Chairman: L. M. Arrowsmith, B.SC.; *Vice-Chairman:* R. M. Epps
Hon. Secretary: K. S. Millington, 14 Derwent Road, Redcar, Yorks.

NORTH MIDLAND CENTRE

Chairman: Prof. G. W. Carter, M.A.
Past-Chairmen: G. Caton; W. K. Fleming; A. J. Coveney; J. D. Nicholson, B.SC.
Vice-Chairmen: W. J. A. Painter; G. N. Patchett, B.SC., PH.D.
G. Auton
M. E. Broadbent
O. I. Butler, D.SC.
J. F. Cunningham
T. Duerden, B.SC.TECH.
F. W. Fletcher
D. C. Graham, B.SC.(ENG.)
A. Haddock, B.SC.
H. Hurworth
P. C. Phillips, B.SC.(ENG.)
Col. M. A. Philp
A. R. Rumfitt
L. E. Ryall, PH.D.(ENG.)
R. Spence
J. Sykes
F. G. Tyack
J. F. Wilson

Ex officio: J. R. Rylands, M.SC., J.P.
Hon. Secretary: H. A. Carr, c/o A. Reyrolle and Co. Ltd., 20 St. Paul's Street, Leeds 1
Hon. Asst. Secretary: J. N. B. Griffiths, 48 Cornwall Road, Harrogate, Yorks.
Hon. Treasurer: J. Lawton, 42 Leadhall Lane, Harrogate, Yorks.

SHEFFIELD SUB-CENTRE

Chairman: F. G. Tyack
Past-Chairmen: F. A. Benson, D.ENG., PH.D.; O. I. Butler, D.SC.
Vice-Chairmen: H. Anderson; E. J. Lilleker
M. F. Bracey, B.ENG.
B. G. Cryer
Prof. A. L. Cullen, PH.D., B.SC.(ENG.)
I. B. Davidson
D. McFarland, B.SC.
G. L. Mason
H. Newsam, B.SC.(ENG.)
H. Peace
J. R. Phillips, M.A
J. W. Spooner
W. J. Wilson

Hon. Secretary: J. E. Caldwell, B.SC.(ENG.), 5 Cockshutt Road, Beauchief, Sheffield
Hon. Asst. Secretary: D. N. Roberts, B.ENG., 303 Fulwood Road, Sheffield 10
Hon. Treasurer: F. Seddon, Beechcroft, Townhead Road, Dore, Sheffield

NORTH MIDLAND UTILIZATION GROUP

Chairman: G. Auton
Vice-Chairman: W. Paterson, B.SC.
F. Clarke
G. A. Farthing, T.D.
F. R. Harrison
H. Moorhouse
D. Pitts
H. J. Towse, B.SC.(ENG.)

Ex officio: A. R. Rumfitt (Past-Chairman); H. A. Carr; F. W. Fletcher; G. W. Green
Hon. Secretary: E. R. W. Brinkworth, c/o George Ellison Ltd., Norwich Union Building, City Square, Leeds 1

North Midland Graduate and Student Section

Chairman: G. W. Green
Vice-Chairman: C. D. Stone
Hon. Secretary: D. B. Wardman, 6 Sunny Bank Grove, Bracken Edge, Leeds 8

Sheffield Graduate and Student Section

Chairman: B. G. Cryer
Vice-Chairman: J. Allison, B.SC.(ENG.), PH.D.
Hon. Secretary: M. F. Bracey, B.ENG., Dept. of Electrical Engineering, The University, Mappin Street, Sheffield 1

NORTH-WESTERN CENTRE

Chairman: F. J. Hutchinson, M.ENG.
Past-Chairmen: G. V. Sadler; T. E. Daniel, M.ENG.; F. R. Perry, M.SC.TECH.; Prof. F. C. Williams, O.B.E., D.SC., D.PHIL., F.R.S.
Vice-Chairmen: C. H. Flurscheim, B.A.; F. Linley
J. W. Binns
R. W. Blower, B.SC.(ENG.)
F. W. Gee, B.SC.TECH.
C. P. Holder, B.A.
J. C. Jones
W. N. Kilner
E. R. Laithwaite, M.SC., PH.D.
W. McDermott, B.SC.TECH.
N. Newton
A. C. Normington, B.SC.(ENG.)
J. E. Peters, B.SC.TECH.
W. D. Sutcliffe

Ex officio: Sir Vincent Z. de Ferranti, M.C.; Sir Willis Jackson, D.SC., F.R.S.; H. West, M.SC.; J. R. Mortlock, PH.D., B.SC.(ENG.); Chairmen of the Group Committees; Chairman and Hon. Secretary of the North Lancashire Sub-Centre; Chairman of Graduate and Student Section; Chairman of the Education Discussion Circle
Hon. Secretary: H. Diggle, B.SC.TECH., Associated Electrical Industries Ltd., Transformer Division, Southmoor Road, Wythenshawe, Manchester 23
Hon. Treasurer: C. F. Tyrrell, 'Kinder', Ley Hey Road, Marple, Stockport, Cheshire

NORTH LANCASHIRE SUB-CENTRE

Chairman: O. Seymour
Past-Chairmen: H. G. Cope; C. E. Smith, B.SC.(ENG.)
Vice-Chairmen: C. C. Bacon; F. Clegg
W. J. Brown, B.SC.(ENG.)
Lt.-Col. A. B. Whatman, M.B.E., M.A.
R. J. C. Tarr, B.SC.
W. G. Walker
A. Wilson, B.SC.(ENG.)

Hon. Secretary and Treasurer: F. Day, North Western Electricity Board, 40/41 Lune Street, Preston
Hon. Asst. Secretary: A. Bartlett, 99 Black Bull Lane, Fulwood, Preston

NORTH-WESTERN MEASUREMENT AND CONTROL GROUP

Chairman: E. J. R. Hardy, B.SC.(ENG.)
Vice-Chairman: A. Chorlton, B.SC.TECH.
J. Dean
R. N. H. McMillan, B.A.
J. Rawcliffe, M.SC.TECH.
J. L. Russell
E. C. Smith

Ex officio: T. Kilburn, M.A., PH.D., D.SC. (Past-Chairman); Chairman and Hon. Secretary of the North-Western Centre
Hon. Secretary: R. W. Fryer, 2 Rossett Avenue, Timperley, Altrincham, Cheshire

NORTH-WESTERN ELECTRONICS AND COMMUNICATIONS GROUP

Chairman: S. D. Mellor, B.ENG.
Vice-Chairman: C. Heys

W. R. Fletcher, B.SC.(ENG.) C. N. W. Litting, PH.D., B.SC.
R. M. Johnstone, B.SC.(ENG.) A. G. S. Smith
J. Knox, M.SC.

Ex officio: R. Feinberg, DR.ING., M.SC. (Past-Chairman); Chairman and Hon. Secretary of the North-Western Centre

Hon. Secretary: J. Dalton, 12 Cedar Avenue, Claypool Road, Horwich, Lancs.

NORTH-WESTERN SUPPLY GROUP

Chairman: A. C. Ehrenberg

Vice-Chairman: F. Gee

R. W. Blower, B.SC.(ENG.) F. W. Taylor, M.SC.TECH.
E. W. Connon, B.SC.(ENG.), M.ENG. L. Wain
J. V. Werrell, B.SC.(ENG.)
A. J. Gray, B.SC.(ENG.)

Ex officio: J. Whitfield (Past-Chairman); J. E. Peters, B.SC.TECH.; C. H. Flurscheim, B.A.; J. R. Mortlock, PH.D., B.SC.(ENG.); Chairman and Hon. Secretary of the North-Western Centre

Hon. Secretary: J. B. Kilshaw, System Planning and Design Engineer, North Western Electricity Board, No. 3 Sub-Area, Union Street, Oldham, Lancs.

NORTH-WESTERN UTILIZATION GROUP

Chairman: W. E. G. Robinson, B.SC.(ENG.)

Vice-Chairman: C. Ayres, B.SC.(ENG.)

H. J. Bridge A. M. Dennison
E. T. Bostock, B.ENG. D. S. Marshall
W. G. H. Chilvers

Ex officio: J. N. M. Legate, B.SC. (Past-Chairman); Chairman and Hon. Secretary of the North-Western Centre

Hon. Secretary: W. F. Jarvis, 8 Fairview Road, Timperley, Cheshire

North-Western Graduate and Student Section

Chairman: G. B. Popple

Vice-Chairman: D. F. Binns, M.SC.

Hon. Secretary: I. W. Wright, B.SC., 77 Broadway, Worsley, Manchester

NORTHERN IRELAND CENTRE

Chairman: T. S. Wylie

Past-Chairmen: C. M. Stoupe, B.SC.; D. S. McIlhagger, PH.D., M.SC.

Vice-Chairmen: J. McA. Irons; W. Szwander, DIPL.-ING.

C. R. S. Agnew, B.SC. F. W. Cox, B.SC.(ENG.)
H. F. Blair W. J. A. Lowry, B.SC.
A. A. Bromley, M.SC.

Hon. Secretary: R. L. Marrs, B.SC., 'Chez Moi', Mosside Road, Dunmurry, Co. Antrim

Hon. Asst. Secretary: W. H. Farmer, Room 49, Telephone House, 1 Cromac Street, Belfast

Hon. Treasurer: Maj. J. E. Jones, B.SC., 21 Park Road, Belfast

Northern Ireland Graduate and Student Section

Chairman: A. A. Marshall

Vice-Chairman: H. McKillen

Hon. Secretary: J. B. Harson, B.SC., 10 Chichester Road, Belfast

SCOTTISH CENTRE

Chairman: J. A. Aked, M.B.E.

Past-Chairmen: E. Wilkinson, PH.D., B.ENG.; Prof. E. M. Bruce, M.SC., PH.D.; E. O. Taylor, B.SC., F.R.S.E.; R. J. Rennie, B.SC.

Vice-Chairmen: R. B. Anderson; W. B. Laing; T. R. Warren, M.A., B.SC.(ENG.)

C. M. Beckett, T.D., M.A. E. H. Jones, DIPL.-ING.
R. H. Dean, B.SC.TECH. W. H. P. Leslie, B.SC.
W. S. Fowlie Maj. W. M. Mackay, M.C., T.D., B.SC.
D. S. Gordon, B.SC., PH.D.
J. Jamieson, B.SC., PH.D. J. K. Wheeldon

Ex officio: T. G. N. Haldane, M.A.; Prof. M. G. Say, PH.D., M.SC., F.R.S.E.

Hon. Secretary and Treasurer: J. H. P. de Villiers, A.H.-W.C., Bruce Peebles and Co. Ltd., 19 Waterloo Street, Glasgow C.2

NORTH SCOTLAND SUB-CENTRE

Chairman: A. J. O. Cruickshank, B.SC.(ENG.), PH.D.

Past-Chairmen: Prof. E. G. Cullwick; S. R. Urquhart, O.B.E., M.A., D.SC.

Vice-Chairmen: L. F. Dorward, B.SC.; G. L. Doig, B.SC.(ENG.)

J. A. Bennet, B.SC., PH.D. T. M. McCammont
J. W. Budge J. S. Oliver
J. E. Dadswell

Ex officio: J. A. Aked, M.B.E.; R. B. Anderson; J. H. P. de Villiers, A.H.-W.C.; W. S. Fowlie; Major W. M. Mackay, M.C., T.D., B.SC.; A. W. Ogilvy; P. Philip, O.B.E.; E. Wilkinson, PH.D., B.ENG.; P. M. Will

Hon. Secretary: K. J. McConnell, c/o Jute Industries Ltd., Engineering Dept., Tay Carpet Works, Lochee Road, Dundee

Hon. Asst. Secretary: J. C. Earls, B.SC.(Eng.), c/o Electrical Engineering Dept., Robert Gordon's Technical College, Aberdeen

Hon. Treasurer: G. L. Doig, B.SC.(ENG.), 7 Reform Street, Monifieth, Angus

North Scotland Graduate and Student Section

Chairman: J. B. Izatt, B.SC.

Vice-Chairman: U. E. O. Uchenyi

Hon. Secretary: P. M. Will, B.SC., c/o Electrical Engineering Dept., Robert Gordon's Technical College, Aberdeen

SOUTH-EAST SCOTLAND SUB-CENTRE

Chairman: D. M. Thornton, B.SC.

Past-Chairmen: F. G. Bennett; J. Mendelson

Vice-Chairman: I. S. Fraser, B.SC.

A. J. Bode T. Moxon
W. E. J. Farvis, B.SC., B.SC.(ENG.) H. B. Stansfield, B.SC.
A. A. B. Martin, B.SC. J. Stewart, M.A., B.SC.

Ex officio: J. A. Aked, M.B.E.; C. M. Beckett, T.D., M.A.; J. H. P. de Villiers, A.H.-W.C.; T. G. N. Haldane, M.A.; W. B. Laing; E. O. Taylor, B.SC., F.R.S.E.

Hon. Secretary: G. I. Thomas, B.SC., Ferranti Ltd., Ferry Road, Edinburgh 5

Hon. Asst. Secretary: J. B. McPherson, 'Forthview', Haddington Road, Tranent, East Lothian

Hon. Treasurer: A. R. S. Robertson, c/o Mrs. Sims, 15 Telford Road, Blackhall, Edinburgh

South-East Scotland Graduate and Student Section

Chairman: G. E. Woolley, B.SC.

Hon. Secretary and Vice-Chairman: G. J. H. Brooking, A.R.C.S.T., c/o Bruce Peebles and Co. Ltd., 37 Inverleith Place, Edinburgh 3

SOUTH-WEST SCOTLAND SUB-CENTRE

Chairman: J. E. Sayers, B.SC.

Past-Chairmen: A. J. Small, B.SC., PH.D.; W. Adam, B.SC.

Vice-Chairmen: W. L. Kidd, B.SC.TECH.; H. B. Hughes, B.SC.(ENG.)

W. J. A. Gemmell, B.SC. Z. J. Jelonek, DIPL.-ING.
J. T. Henderson, B.SC. D. MacDougall
W. H. Howard W. L. Morton

Ex officio: J. A. Aked, M.B.E.; Prof. F. M. Bruce, M.SC., PH.D.; J. H. P. de Villiers, A.H.-W.C.; D. S. Gordon, B.SC., PH.D.; J. Jamieson, B.SC., PH.D.; E. H. Jones, DIPL.-ING.; W. H. P. Leslie, B.SC.; R. J. Rennie, B.SC.; T. R. Warren, M.A., B.SC.(ENG.); J. K. Wheeldon

Hon. Secretary and Treasurer: D. W. Gregory, c/o Johnson and Phillips Ltd., 59 Berkeley Street, Glasgow C.3

Hon. Asst. Secretary: D. R. Rollo, B.SC.(ENG.), 44 Woodhead Avenue, Kirkintilloch, Glasgow

South-West Scotland Graduate and Student Section

Chairman: C. G. Gordon, B.SC.

Vice-Chairman: P. L. V. Pomella, B.SC.

Hon. Secretary: W. J. Hall, c/o English Electric Co. Ltd., 200 St. Vincent Street, Glasgow C.2

SOUTH MIDLAND CENTRE

Chairman: G. F. Peirson

Past-Chairmen: L. L. Tolley, B.SC.(ENG.); J. Ashmore

Vice-Chairmen: Brig. F. Jones, C.B.E., M.SC.; C. F. Freeman, B.SC.(ENG.)

R. J. Anderson, T.D., B.SC.(ENG.) D. L. Meyrick, B.SC.(ENG.)
L. D. Anscombe, M.A. F. W. Skelcher
J. E. Boul, A.C.G.I. J. Terry
H. M. Fricke, B.SC. D. N. Truscott, O.B.E., PH.D., B.SC.(ENG.), SC.D.
H. M. Gale, B.SC.(ENG.)
R. A. Joseph, B.SC. Prof. D. G. Tucker, D.SC., PH.D.

Hon. Secretary: E. H. Cox, Midlands Electricity Board, Mucklow Hill, Halesowen, Birmingham

Hon. Asst. Secretary: J. C. Pyatt, Nechells 'B' Power Station, Nechells, Birmingham 7

Hon. Treasurer: J. H. Addenbrooke, 58 Wolverhampton Road, Birmingham 32

NORTH STAFFORDSHIRE SUB-CENTRE

Chairman: A. Asbury, B.SC.

Past-Chairmen: R. W. Palmer; A. T. Chadwick

Vice-Chairmen: G. H. Gillam; T. E. Calverley, B.SC.(ENG.), PH.D

H. Baker, B.SC. F. L. Fletcher, B.SC.(ENG.)
H. S. Brown, B.ENG. L. Goodall
W. N. Burns E. Jones, B.SC.(ENG.)
A. R. Buttrey, B.SC. K. A. Mackenzie
J. A. P. Firth M. R. Ward, B.SC.(ENG.)

Ex officio: J. E. Boul, A.C.G.I.; Sir George H. Nelson, BART.; J. M. Ferguson, B.SC.(ENG.)
Hon. Secretary: P. W. R. Gatliff, B.SC., English Electric Co. Ltd., Stafford
Hon. Asst. Secretaries: A. P. Baines, 51 Springfield Drive, Mosspitt, Stafford; (*Stoke*) P. Finch, 14 Brookfield Avenue, Endon, Stoke on Trent; (*Stone*) C. E. Woolley, K8 Raleigh Hall, Eccleshall, Staffs.
Hon. Treasurer: W. T. Warnock, Post Office Central Training School, Duncan Hall, Stone, Staffs.

North Staffordshire Graduate and Student Section

Chairman: T. E. S. Rickard, B.SC.; *Vice-Chairman:* D. J. Andrews, B.SC.
Hon. Secretary: D. J. Aylott, M.A., Transformer Works, English Electric Co. Ltd., Stafford

RUGBY SUB-CENTRE

Chairman: W. J. Gibbs, D.SC.
Past-Chairmen: E. M. Price, M.A.; W. J. Carfrae, B.SC.
Vice-Chairmen: E. S. Hall; K. J. R. Wilkinson, D.SC.

R. C. Davis
R. Dunsmuir, B.SC., M.SC., PH.D.
J. W. Lincoln
W. K. Low, B.SC.
J. Metcalfe, M.B.E., B.SC.
J. P. Quayle, B.SC.(ENG.)
L. Roullier
W. Spence, B.SC.

Ex officio: G. S. C. Lucas, O.B.E., F.C.G.I.; L. Drucquer
Hon. Secretary: J. Richmond, M.B.E., B.ENG., 53 Vernon Avenue, Rugby
Hon. Asst. Secretaries: R. W. Robinson, 51 Yates Avenue, Newbold Glebe, Rugby; A. J. Gilbert, B.A., c/o Plant Engineering Dept., British Thomson-Houston Co. Ltd., Rugby
Hon. Treasurer: P. G. Ross, B.SC., 10 Fareham Avenue, Rugby

Rugby Graduate and Student Section

Chairman: P. J. G. Hetzel, M.SC.; *Vice-Chairman:* T. J. Roberts, B.SC.
Hon. Secretary: D. C. Macdonald, B.SC.(ENG.), c/o Plant Engineering Dept., A.E.I. Heavy Plant Division, Rugby

SOUTH MIDLAND ELECTRONICS AND MEASUREMENT GROUP

Chairman: K. B. Wilson, B.SC.(ENG.)
Past-Chairman: J. S. Roebuck, B.SC.
Vice-Chairman: H. M. Gale, B.SC.(ENG.)

T. P. Douglas, M.B.E.
J. W. R. Griffiths, B.SC., PH.D.
J. M. Harvey, B.SC.(ENG.)
H. F. Jones, B.SC.(ENG.)
A. D. Matthews, B.SC.
G. A. Probert
F. D. Rawcliffe, B.SC.(ENG.)
R. E. Young, B.SC.(ENG.)

Hon. Secretary: E. S. Johnson, c/o Telephone Manager, 63 Hagley Road West, Birmingham 17

SOUTH MIDLAND SUPPLY AND UTILIZATION GROUP

Chairman: E. V. Hardaker, B.SC.; *Vice-Chairman:* H. M. Fricke, B.SC.

S. F. Adcock
F. C. Barford, T.D.
F. N. Dalman, B.SC.
J. A. Fitzpatrick
J. Hamilton, M.ENG.
E. J. Hand
D. J. Smith

Ex officio: J. R. Anderson, T.D., B.SC.(ENG.) (*Past-Chairman*); G. S. Buckingham, B.SC.(ENG.); W. G. Thompson, PH.D., B.SC.
Hon. Secretary: H. C. Fox, George Ellison Ltd., Perry Barr, Birmingham 22B

South Midland Graduate and Student Section

Chairman: J. M. Harvey, B.SC.(ENG.); *Vice-Chairman:* N. E. Bastable
Hon. Secretary: G. A. Raley, 113 Castleton Road, Beeches Estate, Great Barr, Birmingham 22A

SOUTHERN CENTRE

Chairman: W. D. Mallinson, B.SC.(ENG.)
Past-Chairmen: L. H. Fuller, B.SC.(ENG.); H. Robson, B.SC.; G. Bishop, B.SC.; L. G. A. Sims, M.SC., PH.D., D.SC.
Vice-Chairmen: R. Goford; T. McGreevy, M.SC.TECH.; T. G. C. Harrop, B.E.M.; J. H. Mole, PH.D., B.SC.(ENG.)

T. E. Allibone, D.SC., PH.D., F.R.S.
S. T. Flannery, B.SC.(ENG.)
J. L. Harland
J. P. Harvey, B.SC.(ENG.)
V. G. Hoptroff
R. Lonsdale
E. McCabe
D. McCarthy
H. K. Maddams, B.SC.
O. L. Ratsey, M.A.
Cmdr. C. V. Robinson, O.B.E., R.N.(RET.)
R. Summarsell
R. F. Whitworth

Ex officio: E. Leete
Hon. Secretary: H. W. Housley, 15 Southdown Road, East Cosham, Portsmouth, Hants.
Hon. Asst. Secretaries: A. C. Tremain, B.SC.(ENG.), Municipal College, Portsmouth, Hants.; C. G. Brammer, 48 Brecon Avenue, East Cosham, Hants.
Hon. Treasurer: W. M. Read, 11 Bath Road, Bournemouth, Hants.

Southern Graduate and Student Section

Chairman: H. K. Maddams, B.SC.
Vice-Chairman: A. R. Roby
Hon. Secretary: R. F. Whitworth, 23 Alton Grove, Portchester, Fareham, Hants.

WESTERN CENTRE

Chairman: H. Jackson, B.SC.(ENG.)
Past-Chairmen: R. W. Steel; J. F. Wright; Prof. G. H. Rawcliffe, M.A., D.SC.; T. G. Dash, J.P.
Vice-Chairmen: A. C. Thirtle; T. Gill, B.SC.

C. T. Baldwin, M.A.
C. J. R. Blackett
N. Care
A. R. Daniels, M.SC.
E. N. Evans
A. H. McQueen
E. J. Mathieson
J. K. Phelps
G. Redfern, M.A.
W. T. Roper
D. P. Sampson
P. Smith, B.SC.
H. E. Vickers
E. W. S. Watt
W. L. Williams

Ex officio: A. G. R. Bell; C. Evans; D. C. Flack, B.SC.(ENG.), PH.D.; E. J. H. Marshall; J. Harley; Sir Hamish D. MacLaren, K.B.E., C.B., D.F.C., LL.D., B.SC.
Hon. Secretary: D. Stephens, 7 Clovelly Crescent, Llanrumney, Cardiff
Hon. Asst. Secretary (*Bristol*): W. D. Morgan, 'Green Lea', Farleigh, Backwell, nr. Bristol
Hon. Asst. Secretary (*Cardiff*): W. Real, 14 Manor Rise, Whitchurch, Cardiff
Hon. Treasurer: David J. Thomas, 2 St. Andrew's Place, Cardiff

SOUTH-WESTERN SUB-CENTRE

Chairman: A. G. R. Bell
Past-Chairman: Capt. W. W. H. Ash, A.D.C., R.N.
Vice-Chairmen: H. K. Heppell, M.ENG.; F. C. Isaac

F. Bowles
W. G. Clarke
D. Dempster, B.SC., PH.D.
G. B. Devey
J. E. Flower
D. George
W. E. Johnson
L. J. M. Kirkby, D.F.H.
D. H. MacNee, B.SC.
H. C. O. Stanbury, B.SC.(ENG.)

Hon. Secretary: E. J. H. Marshall, c/o South Western Electricity Board, 136 High Street, Crediton, Devon
Hon. Asst. Secretary: Lt.-Cmdr. A. O. H. Ashthorpe, 151 Fort Austin Avenue, Crownhill, Plymouth, Devon
Hon. Treasurer: R. H. Upton, M.ENG., 3 Raddenstile Lane, Exmouth, Devon

WEST WALES (SWANSEA) SUB-CENTRE

Chairman: J. Harley
Past-Chairmen: I. G. Evans; T. Gill, B.SC.
Vice-Chairmen: J. Nelsey, B.SC.(ENG.); W. E. Lewis, B.SC., PH.D.

C. J. Beavis
D. Cameron, B.SC.(ENG.)
A. Evans
G. E. Evans, B.SC.
Prof. W. Fishwick, M.A., PH.D.
H. M. Hughes, M.A.
E. J. Pearce

Hon. Secretary: C. Evans, 38 Old Road, Llanelly, Carmarthenshire
Hon. Asst. Secretary: D. H. Hughes, 5 Hillside, Furnace, Llanelly, Carmarthenshire
Hon. Treasurer: O. J. Mayo, 52 Cromwell Street, Mount Pleasant, Swansea

WESTERN SUPPLY GROUP

Chairman: N. Care
Vice-Chairman: A. H. McQueen

T. S. Andrew
F. G. Copland, B.ENG.
H. Jackson, B.SC.(ENG.)
J. S. Lombard, B.SC.(ENG.)
C. Morley New
D. Stephens
D. J. Thomas, B.SC.(ENG.)
H. E. Vickers

Ex officio: A. G. Milne, C. J. R. Blackett (Past-Chairmen); Chairman and Hon. Secretary of the Western Centre
Hon. Secretary: A. A. Beckingsale, Electricity House, Colston Avenue, Bristol 1

WESTERN UTILIZATION GROUP

Chairman: P. Smith, B.SC.
Past-Chairmen: C. E. Dew; F. J. Baber
Vice-Chairmen: E. Hawkesley; R. L. Russell, D.SC.

J. P. Buck, B.SC.(ENG.)
K. Druce
C. H. H. Pease, B.SC.(ENG.)
S. R. A. Phelps
T. L. Purves
P. H. Yeo

Ex officio: Chairman and Hon. Secretary of the Western Centre
Hon. Secretary: W. S. Evans, Broad Oak, 3 Heol Wen, Rhiwbina, Cardiff
Hon. Asst. Secretary: A. R. S. Gough, 'Greenacres', Hempton Lane, Almondsbury, Bristol

Bristol Graduate and Student Section

Chairman: A. R. Daniels; *Vice-Chairman:* J. Rose

Hon. Secretary: A. R. W. Broadway, B.SC., 14 Alexandra Park, Redland, Bristol 6

Cardiff Graduate and Student Section

Chairman: J. K. Phelps; *Vice-Chairman:* A. W. Hart

Hon. Secretary: M. J. Hughes, Ryecroft, Greenhill Road, Griffithstown, Pontypool, Mon.

Oversea Branches, Representatives, Committees, and Joint Groups, 1959-60

Oversea Branches

BOMBAY BRANCH

Chairman: J. C. Patel, B.SC.; *Vice-Chairman:* S. R. Kantebet, B.A.

R. P. Desai, B.SC.
P. W. Dharap, B.A.
R. K. Gurtu, B.SC.
D. D. Lakhanpal, B.A., B.SC.TECH.
K. C. Maitra, B.SC., M.SC.
S. C. B. Mazumder, B.SC.
S. Szafranski, B.SC.
P. L. Verma, B.SC.
S. M. Zubair, M.SC.

Hon. Secretary: T. M. Shivram, Services Engineer (North), B.E.S. and T. Undertaking, Electric House, Post Fort, Bombay 1

CALCUTTA BRANCH

Chairman: H. C. Hardy; *Past-Chairman:* D. H. P. Henderson

Vice-Chairmen: C. Rowe; P. N. Mukherji, M.SC.

A. K. Bhaumik, B.SC.(ENG.)
H. C. Bowker, B.SC.(ENG.), PH.D.
M. Data, M.SC.TECH., PH.D.
G. L. R. Dawson, B.SC.(ENG.)
J. H. Hanson, B.SC.
W. R. Henley
R. G. Mukherjee, M.SC.
H. E. M. Myers
N. B. Sajnani, B.SC.

Ex officio: F. Wade-Cooper

Hon. Secretary: L. W. Brazel, Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta

CEYLON BRANCH

Chairman: Prof. R. H. Paul, M.A., B.SC.

Past-Chairman: E. C. Fernando, M.B.E., B.SC.(ENG.)

Vice-Chairman: C. A. R. Anketell, B.SC.(ENG.)

K. V. Alagaratnam
R. Canagarayar, B.SC.TECH.
A. Ragunather, B.SC.
J. H. B. Robins, B.SC.(ENG.)
C. P. Sriwardena, B.SC.(ENG.)
L. W. G. Starbuck
T. S. V. Tillekeratne
D. de S. Weerasena

Ex officio: J. G. Park

Hon. Secretary: M. I. Aziez, B.SC., Electrical Engineer, Operations and Maintenance, Dept. of Government Electrical Undertakings, P.O. Box 540, McCallum Road, Colombo 10

IRISH BRANCH

Chairman: T. P. Hogan, B.E.

Past-Chairmen: R. L. S. McDowell, B.SC.; L. Collins, B.E., B.SC.

Vice-Chairmen: C. V. O'Donnell, M.E.; J. A. V. McEvoy, B.E.

R. C. Cuffe, B.E., PH.D.
W. Dain
L. B. P. D'Alton, M.E.
H. L. De Lacey, B.E., B.SC.
J. D. Ferguson, B.SC.(ENG.)
P. H. Greer
A. J. Litton, B.E., B.SC.
E. J. Slowey, B.SC.(ENG.)

Hon. Secretary: J. McKeever, B.SC.(ENG.), General Electric Co. Ltd., Magnet House, Adelaide Road, Dublin

Hon. Asst. Secretary: C. A. McLoughlin, B.SC., c/o Electricity Supply Board, 21 Lower Fitzwilliam Street, Dublin

Hon. Treasurer: B. Magill, B.SC., c/o Brown Boveri (Ireland) Ltd., 192 Pearse Street, Dublin

Irish Graduate and Student Section

Chairman: D. J. Hogan; *Vice-Chairman:* K. G. Egar

Hon. Secretary: A. J. Duffy, 32 Upper Baggot Street, Dublin

Oversea Representatives of the Council

ARGENTINA

B. G. Borissow, B.SC.(ENG.), c/o Metropolitan-Vickers Export Co. Ltd., Avda. Roque Saenz Pena 636, 7° Piso, Buenos Aires

BRAZIL

E. Winstanley, B.SC.(ENG.), Rio de Janeiro Flour Mills and Granaries Ltd., Caixa Postal 486, Rio de Janeiro

BURMA

C. H. Mellor, c/o Rangoon Electric Board, 503/9 Merchant Street, Rangoon

CANADA

J. M. Thomson, M.A.SC., PH.D., Ferranti-Packard Electric Ltd., Industry Street, Toronto 15, Ontario

(*Alberta*) Prof. J. A. Harle, M.SC., Head of Department of Electrical Engineering, University of Alberta, Edmonton; (*Ontario*) F. S. Barton, C.B.E., M.A., B.SC., 16 Roxborough Apartments, Laurier Avenue W., Ottawa; (*Quebec*) F. L. Lawton, B.A.SC., c/o Aluminium Laboratories Ltd., 1800 Sun Life Building, Montreal

CAPE PROVINCE

C. G. Downie, B.SC., c/o City Electricity Dept., P.O. Box 82, Cape Town

CEYLON

D. M. Gill, c/o Ceylon Rediffusion Service Ltd., P.O. Box 1002, Colombo

EAST AFRICA

A. O. Cosgrove, B.SC., General Electric Co. Ltd., P.O. Box 5100, Nairobi

Deputy Representatives (*Uganda*): J. M. Stock O.B.E., M.ENG., Uganda Electricity Board, Kampala; (*Tanganyika*) J. H. Griffiths, c/o Public Works Dept. Headquarters, Dar es Salaam, Tanganyika

FAR EAST

D. S. Hill, Reiss, Bradley and Co. Ltd., National City Bank of New York Building, 2 Queen's Road C, Hong Kong

FRANCE

P. M. J. Ailleret, Électricité de France, 12 Place des États-Unis, Paris (16e)

Deputy Representative: R. A. Tellier, ING.É.S.É., c/o Électricité de France, 12 Place des États-Unis, Paris (16e)

INDIA

F. Wade-Cooper, Magnet House, Chittaranjan Avenue, P.O. Box 8974, Calcutta 13

Deputy Representatives: L. W. Brazel, Calcutta Electric Supply Corporation Ltd., Victoria House, Calcutta

(*Bombay*) J. H. Smythe, B.SC., Greaves, Cotton and Crompton Parkinson Ltd., 1 Forbes Street; (*Delhi*) Shiv Narayan, SC.D., M.SC., B.E., M.A., B.SC., 2547 Nai Wara, 6; (*Madras*) J. Meek, B.SC.(ENG.), c/o General Electric Co. (India) Ltd., Magnet House, Mount Road, P.O. Box 351

ISRAEL

B. F. Moss, 94 Hayarkon Street, Tel Aviv

MALAYA AND SINGAPORE

W. Trafford, M.B.E., Telecommunications Dept. (Special Services), Fullerton Building, Singapore 1

Deputy Representative: F. R. Wardrop, B.SC.(ENG.), Central Electricity Board, P.O. Box 1003, Kuala Lumpur

NATAL

R. M. O. Simpson, c/o Electricity Dept., P.O. Box 147, Durban

NEAR AND MIDDLE EAST

H. D. Furber, c/o Iraq Petroleum Co. Ltd., Electrical Engineering Dept., P.O. Box 150, Tripoli, Lebanon

Deputy Representatives: (*Near East*) Prof. R. W. Sloane, M.A., PH.D., B.SC., Director of the Engineering Experimental and Service Laboratories, American University of Beirut, Beirut, Lebanon; (*Middle East*) H. W. S. Marshall, P.O. Box 61, Baghdad, Iraq

NEW SOUTH WALES

J. T. Rollo, I.E.E. Box 701, G.P.O., Sydney (telephone Sydney BO323, Ext. 313)

NEW ZEALAND

G. R. Milne, B.SC., c/o Chief Engineer, Post and Telegraph Department, Wellington

PAKISTAN

A. E. C. Gibson, c/o Associated Electrical Industries (Pakistan) Ltd., Post Box 4958, Karachi

QUEENSLAND

J. S. Just, c/o Box 1067N, G.P.O., Brisbane

RHODESIA
A. B. COWEN, O.B.E., P.O. Box 377, Salisbury

SOUTH AUSTRALIA
G. H. MACHIN, B.E., c/o Electricity Trust of South Australia, Box 412c, G.P.O., Adelaide

SWITZERLAND
L. W. HAYES, O.B.E., 43 Quai Wilson, Geneva

TRANSVAAL AND ORANGE FREE STATE
A. W. LINEKER, B.SC., P.O. Box 7794, Johannesburg

UNITED STATES OF AMERICA
Hon Secretary: R. H. BARCLAY, J. G. White Engineering Corporation, 80 Broad Street, New York 4, N.Y.

VICTORIA AND TASMANIA
PROF. C. E. MOORHOUSE, M.E.E., Department of Electrical Engineering, University of Melbourne, Carlton N.3, Victoria
Deputy Representative for Tasmania: H. P. TUCK, M.E., B.SC., Associate Professor, University of Tasmania, Hobart, Tasmania

WEST AFRICA
J. HOUSTON ANGUS, Private Mail Bag 2031, Lagos, Nigeria

WEST INDIES
H. D. WALDEN, B.SC., Texaco Trinidad Inc., 6 Bon Accord Road, Point-à-Pierre, Trinidad

WESTERN AUSTRALIA
J. B. JUKES, B.E., State Electricity Commission of Western Australia, Electricity House, 321 Murray Street, Perth

Oversea Committees

AUSTRALIA: NEW SOUTH WALES
Chairman: H. B. Wood, B.SC., M.F.

R. M. Barge
R. W. Booth
R. J. P. Green, B.SC.
Prof. D. M. Myers, D.SC.(ENG.), B.SC., B.E.
A. D. Roberts, B.SC., B.E.
Prof. R. E. Vowels, M.E.

Ex officio: J. T. Rollo
Hon. Secretary: D. K. Muir, c/o Electricity Authority of N.S.W., Treasury Basement, Bridge Street, Sydney. Postal Address: I.E.E. Box 701, G.P.O., Sydney

QUEENSLAND
Chairman: A. S. Faulkner

E. B. Freeman, B.ENG.
W. I. Monkhouse
J. E. Morwood
Prof. S. A. Prentice, M.E.E., B.SC.

Ex officio: J. S. Just
Hon. Secretary: W. I. George, B.F., 124 Seventh Avenue, St. Lucia, Brisbane

SOUTH AUSTRALIA
Chairman: Prof. E. O. Willoughby, M.A., B.E.E.
Vice-Chairman: J. W. Harrod, B.SC., M.E.

D. E. Calder, B.E.
B. C. Chase, B.E.
J. W. Crompton, B.E.
G. Ellesworth, B.SC.(ENG.)
M. W. Higgins
F. R. Hill, B.SC.
W. S. Joyner
I. Purdam, B.E.
S. G. F. Ross, B.E.

Ex officio: K. H. Milne, B.E.; A. J. H. Oxford, B.SC.; G. H. Machin, B.E.
Hon. Secretary: E. E. Story, 25 Balham Avenue, Kingswood, Adelaide

VICTORIA AND TASMANIA
Chairman: J. Wilson; *Vice-Chairman:* W. W. Cooper

D. Broadbent, B.SC.
G. T. Cuthbert, B.E.
B. G. Gates, PH.D., B.SC.(ENG.)
C. J. Griffiths, M.E.E.
F. G. Hogg, B.E.
C. G. E. Joslin
Group-Capt. A. G. Pither, R.A.A.F.
H. P. Tuck, B.SC., M.E.
B. Woodfull

Ex officio: C. E. Moorhouse, M.E.E.
Hon. Secretary: D. P. Davies, M.SC., Pen Bryn, Mt. Macedon, Victoria

WESTERN AUSTRALIA
Chairman: K. W. Taplin, B.E.; *Vice-Chairman:* J. B. Jukes, B.E.

D. C. Curtis
F. W. Dawson, B.E.
W. G. Hayman, B.E., B.SC.
P. K. Johns
J. A. Smith

Hon. Secretary and Treasurer: R. R. Lake, B.F., c/o 132 Murray Street, Perth

CANADA: TORONTO
(Oversea Representatives' Advisory Committee)

H. Copping
E. D. Holdup, M.SC.(ENG.)
F. W. Roberts, B.SC.(ENG.)
A. C. Tait
G. S. Wall
N. R. Winter

INDIA: MADRAS
Chairman: R. Wright, M.B.E.

E. H. Brazel
S. Govindarajan, B.SC.TECH.
J. Meek, B.SC.(ENG.)

Hon. Secretary: N. C. S. Kumar, B.SC., c/o Associated Electrical Industries (India) Private Ltd., 35/5 Mount Road (First Floor), P.O. Box 2710, Madras 2

MALAYA AND SINGAPORE
(Oversea Representative's Advisory Committee)

H. W. Goodyear, B.SC.(ENG.)
J. W. Lawton
M. B. Parsons
J. H. Sumner, M.SC.
J. H. Wagstaff, B.SC.(ENG.)

NEW ZEALAND
Chairman: F. T. M. Kissel, I.S.O., B.SC.

S. R. Anstice
R. H. Bartley
Lt.-Col. J. C. Forsyth, B.SC.(ENG.)

Hon. Secretary: G. R. Milne, B.SC., c/o Chief Engineer, Post and Telegraph Dept., Wellington

SOUTH AFRICA
TRANSVAAL AND ORANGE FREE STATE
(Oversea Representative's Advisory Committee)

D. M. Bentley, B.SC.(ENG.)
Prof. G. R. Bozzoli, D.SC.(ENG.)
G. A. Dalton
W. Fenwick
M. Hewitson
W. L. King
A. R. Mullins, B.A.
H. J. H. Nethersole, B.SC.(ENG.)

Joint Groups

ARGENTINA
Chairman: T. B. Glover, M.I.MECH.E.
Hon Secretary and Treasurer: J. Combes, A.M.I.C.E., c/o Percy Grant and Co., Calle Defensa 465, Buenos Aires

BRITISH GUIANA
Chairman: G. A. R. Farquharson, M.I.C.E.
Hon. Secretary: D. S. Fairbairn, A.M.I.C.E., Drainage and Irrigation Department, P.O. Box 26, Georgetown

GHANA
Chairman: T. C. M. Wigg, O.B.E., M.A., A.M.I.C.E.
Hon. Secretary: C. D. Wilkinson, A.M.I.C.E., Telecommunications Engineering School, Accra

GIBRALTAR
Chairman: E. V. Andlaw, M.B.E., M.I.MECH.E., M.I.E.E.
Hon. Secretary: Maj. D. S. Evans, A.M.I.MECH.E., R.E.M.E., 51 Europa Road

HONG KONG
Chairman: G. B. Gifford-Hull, M.I.C.E.
Hon. Secretary: L. F. Roberts, B.SC., M.I.E.E., c/o British General Electric Co. Ltd., Queen's Buildings, Chater Road

MIDDLE EAST
Chairman: C. G. Moore, M.SC., A.M.I.C.E.
Hon. Secretary: D. W. Platt, B.SC.(ENG.), A.M.I.MECH.E., A.M.I.E.E., c/o Kuwait Oil Co. Ltd., Ahmadi, Kuwait, Arabia

SINGAPORE/MALAYA
Chairman: S. E. Jewkes, O.B.E., M.I.C.E.
Hon. Secretary: T. Churchill, A.M.I.MECH.E., Shell Co. of Singapore Ltd., P.O. Box 730, Shell House, Collyer Quay, Singapore

TRINIDAD AND TOBAGO
Chairman: W. T. Boyd, M.I.MECH.E.
Hon. Secretary: D. P. J. Holbrook, B.SC.(ENG.), A.M.I.E.E., c/o Trinidad Oilfield Service Ltd., P.O. Box 69, San Fernando, Trinidad

WEST AFRICA
Chairman: A. G. Baker, A.M.I.E.E.
Hon. Secretary: J. Meade, A.M.I.E.E., Headquarters, Posts and Telegraphs, Lagos, Nigeria